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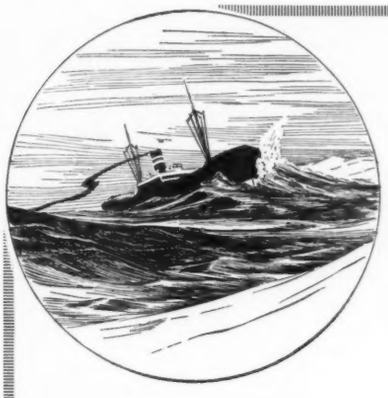

The Life of the Engineer

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By Charles H. Bromi

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YOU say my life's intensely dull,
Monotonous—a stupid lull,
Without a goal to raise hopes high
And that if you were me you'd die?

Now what do you, with unsoiled hands—
Your smooth, clean face and linen bands—
Know of the joys, the frights, the peace,
Found in my world of steel and grease?

At cranky pumps, I've worked and cursed
As tons of sea through great holes burst
And strove to fill the darkened hold
So rapidly my blood ran cold!

In settings hot with glowing soot;
My hide's been scorched from head to foot.
I've put grates back when dropped from place,
While burning coals fell on my face.

Those days are gone and though they had
Their times that almost drove me mad,
What recollections still remain
Are more of pleasure than of pain.

I often think of friends of old,
Case-hardened men with hearts of gold,
Who'd share their last, and gladly too.
Would your pals do as much for you?

And now my task's to work and plan
To get the best that human can
From this big modern plant ashore;
A worthy goal I'm striving for.

Oh, no, young man, a thousand "no's!"
My life's not drear nor dull, God knows!
But yours! 'Tis likely tame, I fear,
Beside that of the engineer.

New Turbine Power Plant of the Louisville Railway Company--I

By W. O. Rogers

SYNOPSIS—A modern steam plant, built on the unit system, with an initial capacity of 12,000 kw. and an ultimate rating of 48,000 kw. The building is constructed to be gradually extended. The handling of fuel and ash and supplying circulating water to the condensers are also features. The circulating pumps are at the bottom of a pit, 35 ft. below maximum high water, and but 3 ft. above the low-water stage of the Ohio River.

The electrical energy for operating 165 miles of city and 96 miles of interurban track prior to the completion of the new High St. power plant, was supplied from the old Campbell St. plant, which had a total rated capacity of 14,600 kw. at 13,200 volts. The old plant was supplanted for several reasons, the two of most importance being the lack of circulating condenser water and the rapid increase in the electrical output.

Circulating water was obtained from Beargrass Creek, on which the plant is situated, and which received the discharge from a number of sewers; it maintained, however, a fairly constant water flow and did not prohibit the use of the water for condensing purposes. Within the past five years the city of Louisville has constructed sewers parallel to the creek, and so diverted the flow of water that sufficient circulating water was not available.

Fig. 1. High Street Power Station

Artesian wells were sunk and a spray cooling system was installed to furnish condensing water, but the water supply was limited and the idea was costly, because of the

Fig. 2. Interior of the High Street Station, Showing the Two 6000-Kv.-A Turbine Units and the Auxiliaries

amount of pumping necessary; the efficiency was materially reduced, and extensions could not profitably be made to the old plant.

Another reason was that the average daily output in the old plant had increased from 35,000 kw.-hr. in 1900 to practically 150,000 at the close of 1912, and the maximum hourly load demand rose from 3000 kw. in 1900 to 14,000 in 1912. This rapid increase in output was due to increased car and track mileage, and to the size and equipment of the cars.

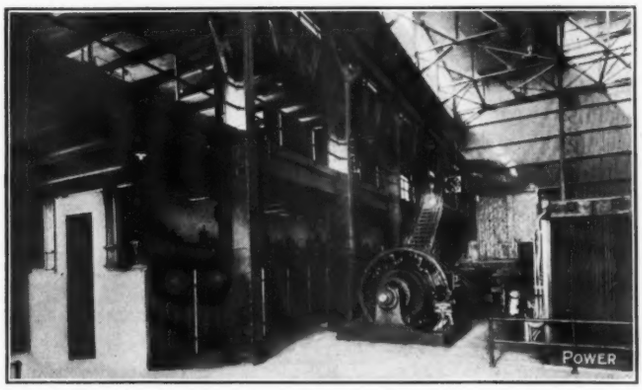


FIG. 3. ROTARY CONVERTER, TRANSFORMERS AND OIL SWITCHES

The new station site is on the Ohio River, but separated from it by the Kentucky & Indiana Terminal R.R. and the Louisville & Portland Canal, the latter having been built as a means of transportation past the rapids during low-stage periods of the river. The power house is above the locks, where there will always be an abundance of water for power-plant consumption.

The new plant site fronts 1358 ft. on the railroad, a part of a double-track line about half-way around the city, and connects with all steam roads entering it. The general level of the property is about 5½ ft. above the maximum high-water stage of the river, and is underlaid with bed rock at a depth of about 36 ft.

Construction work was begun on May 1, 1912, and 19 months later, Nov. 23, 1913, current was first generated. The building, Fig. 1, is of steel, concrete and brick construction, but the west side is closed in with a temporary corrugated siding to be removed when future extensions are made. All foundations and walls up to the high-water line are built of concrete. The concrete foundations of the chimney, turbine and crane columns were built upon bed rock; all other supports rest upon concrete piles driven to bed rock. The roof of the building is made with a 2-in. course of reinforced concrete, a course of 6-in. hollow tile and a 2-in. finishing layer of concrete; the whole is covered with a layer of five-ply tar paper and gravel.

The building includes a 100x180-ft. boiler room built with the longer dimension at right angles to the turbine room, which is 80x175 ft. At the time of the writer's visit, there were two 6000-kv.-a. turbines of the semi-double-flow type, employing the impulse and reaction principles in operation. Steam at 180 lb. and 125 deg. superheat is used in the turbines. The generators are three-phase, 25-cycle, 13,200-volt machines with inclosed ends and forced ventilation. The cooling air is drawn through the cable room from outside the building and passes through copper-wire screens covered with cheese cloth, which catch the dust drawn in with the air.

Fig. 2 is a view of the turbine room looking east toward the permanent end. The condenser and pump pit is between the two main turbines. The electrical-controlling apparatus is on the near side of the room; the auxiliary units are shown on the opposite side under the boiler-room floor.

There are three auxiliary exciter units; 100- and 150-kw. engine-driven, 125-volt generators and one 50-kw. motor-generator set. There is also a 2000-kw., six-phase, 25-cycle, 13,200-volt rotary converter of the latest design. Provision has been made for starting it from either

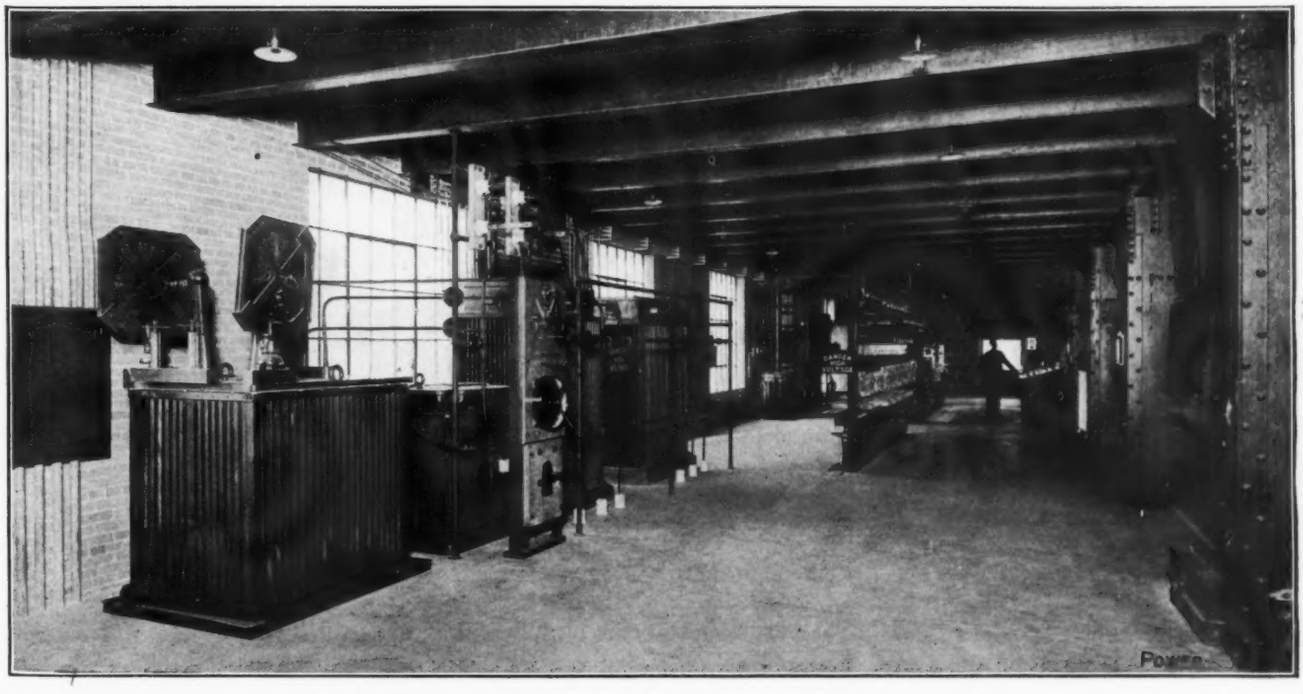


FIG. 4. VIEW OF THE SWITCHBOARD GALLERY, LOOKING WEST

the alternating- or the direct-current end. There are three 750-kw., single-phase, oil-cooled transformers used for the rotary converter, stepping the current down from 13,200 to 380 volts. This equipment, which is tied in with two city substations by way of a 600-volt, direct-current trunk line, is shown in Fig. 3, also the concrete-incased oil switches and high-tension bus structure.

A four-level gallery flanks one side of the turbine room. On the lower one, which is below the turbine-room floor, are the underground transmission conduits. From the conduit the cable radiates through the necessary cable-end bells. The 13,200-volt busbars are in concrete compartments and automatic oil switches are installed over them, being shut in by full-length polished wire-glass

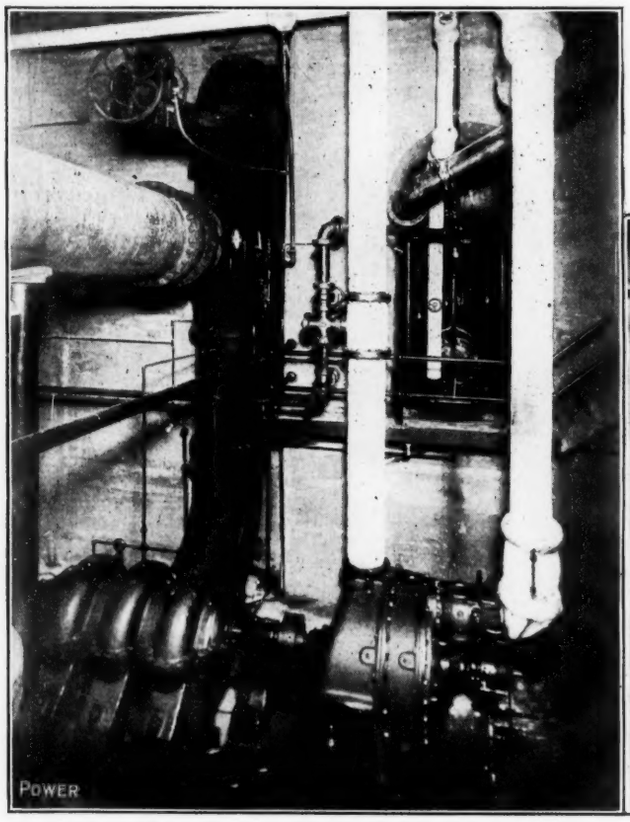


FIG. 5. PUMP PIT, SHOWING PUMPS AND CONCRETE TURBINE FOUNDATION

doors. The switchboards are on the south side of the room on the second gallery. The desk-type control board, in two sections and designed for four generators, has a miniature busbar layout showing the connections of the generators and feeder, also the cross-connections of the bus system. A view of the switchboard floor is shown in Fig. 4.

CONDENSING APPARATUS

A feature not found in the general design of power plant is in connection with the condensing apparatus. Each turbine foundation consists of two parallel walls and extends to within 18 in. of the main turbine floor, which is 12 ft. below the boiler-room floor, thus forming a bay where auxiliaries, pumps, etc., are placed.

The foundation walls are so spaced that the surface condenser may be lowered in place under each turbine by the overhead 50-ton crane. The turbines are on an I-beam grillage, supported by the two concrete foundation walls, the base of which is below the water level of the river, Fig. 5. In Fig. 6 is shown a part of one end of a condenser, one of the two 54-in. electrically operated valves and a 36-in. atmospheric exhaust valve and fittings. The piping is so arranged that the direction of the flow of water can be changed in the condenser by the manipulation of four valves; thus washing the refuse out of the condenser into the discharge tunnel, or any obstruction that might come in with the circulating water. These pumps, Fig. 5, driven by 280-hp., two-stage turbines, are in the condenser pit 35 ft. below the maximum high water and 3 ft. above the low-water stage of the river. The water for condensing purposes is taken from the canal, Fig. 7, and is conveyed to the pump pit through two 7x8-ft. concrete tunnels after passing through wire screens in the screen house.

The top of the eight canal intake openings is about 4 ft. below the normal water level, to eliminate, as much as possible, floating débris and to avoid frequent clogging of the screens. The openings for both the intake

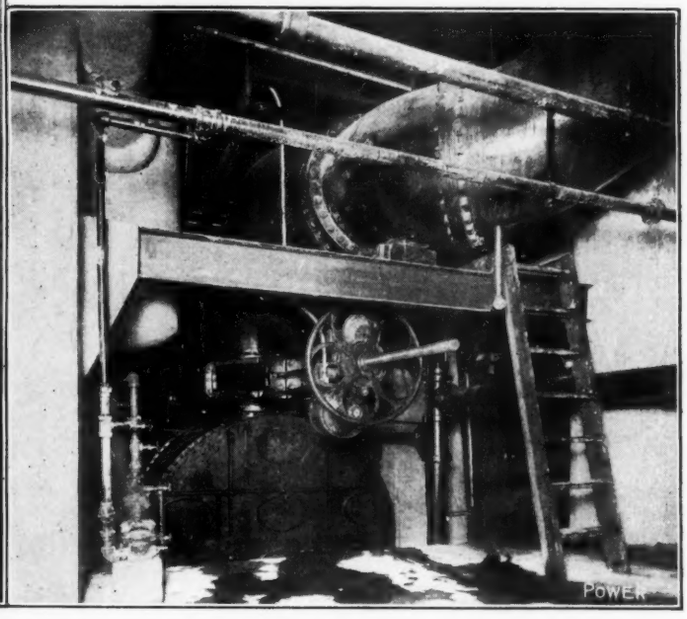


FIG. 6. END VIEW OF ONE OF THE SURFACE CONDENSERS AND MOTOR-OPERATED VALVE

and the discharge are for a flow of 160,000 gal. per min. with a discharge current of 1.19 ft. per sec.; this is necessary so as not to interfere with small boats passing in the canal. This was accomplished by discharging from the bottom and from several outlets. The other end of the tunnels terminate under the circulating pumps in the pump pit.

Two auxiliary 30-in. cast-iron discharge pipes extend from the east end of the discharge tunnel to a point on the canal over the intake. Should the canal water freeze, the discharged hot water can be used to melt any needle ice that may obstruct the tunnel entrance.

In the screen house there are four sets of double, brass-wire screens, two in series. The screens on the intake side have a ¾-in. mesh and those on the other a ½-in. mesh. The screens are mounted on metal frames and the whole can be raised to the floor of the screen room for cleaning, Fig. 8, by a five-ton electric traveling crane.

FIG. 7. CANAL AND SCREEN HOUSE, THE OHIO RIVER IN THE DISTANCE

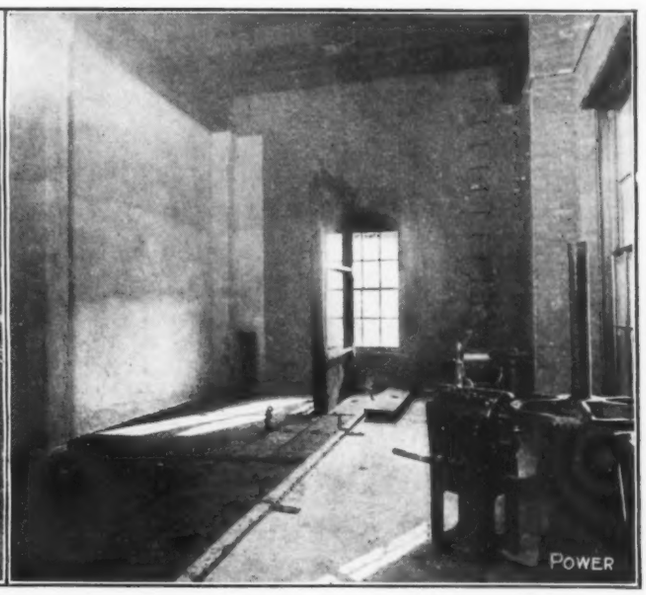


FIG. 8. INTERIOR OF THE SCREEN HOUSE, SHOWING SCREEN CRANE

Each tunnel can be shut off by sluice gates operated from the ground floor by means of worm gears. At the canal end of the tunnel a system of iron-bar racks, placed at 60 deg., and spaced 2½ in. apart, catches all heavy material and prevents damaging the smaller screens.

The concrete discharge tunnel from the condensers is horseshoe in shape, 9x9 ft., and empties into the canal 500 ft. west of the intake. Discharge pits have been built into the discharge tunnel below the flow line to seal the condenser discharge; the water-discharge entrance into the conduit is by means of flanged castings set in the concrete walls.

Condensate is taken from each hotwell by a 4-in. two-stage turbine pump driven by a small turbine. The pumps deliver water from the hotwell to the open heater in the boiler room at a maximum rate of 350 gal. per min. against a head of 60 ft. Makeup water is supplied from an overhead 35,000-gal. capacity steel tank by either of two 9, 14 and 8½ by 15-in. duplex compound pumps. The tank is above the elevator shafts of the boiler room and the water overflows at a height of 119 ft. above the turbine room. A float valve in the tank closes the inlet when the water rises to within 6 in. of the overflow. This action produces pressure on the pump discharge and the regulators automatically stop the pump. An elevation gage, installed over the engineer's desk, is graduated in feet to indicate the height of water in the tank. This water is not only used for makeup but for water-cooled glands in the main turbine, centrifugal pump and exciters.

PRINCIPAL EQUIPMENT OF THE NEW TURBINE PLANT OF THE LOUISVILLE RAILWAY CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Hor. semi double flow	6000 kv.a.	Main units	1500 r.p.m., 180 lb. steam, 125 deg. superheat	Westinghouse Mch. Co.
2	Generators	Alt. current	6000 kv.a.	Main units	1500 r.p.m., 13,200-volt, 3-phase, 25-cycles	Westinghouse Elec. & Mfg. Co.
1	Generator	Direct current	150 kw.	Exciter, turbine driven	2200 r.p.m., 125-volt, turbine driven	Westinghouse Elec. & Mfg. Co.
1	Generator	Direct current	100 kw.	Exciter, turbine driven	1800 r.p.m., 125-volt, turbine driven	Westinghouse Elec. & Mfg. Co.
1	Turbine	Horizontal, impulse	150 kw.	Driving exciter generator	2200 r.p.m., 180 lb. steam, 125 deg. superheat	Westinghouse Mch. Co.
1	Turbine	Horizontal, impulse	100 kw.	Driving exciter generator	1800 r.p.m., 180 lb. steam, 125 deg. superheat	Westinghouse Mch. Co.
1	Converter	Rotary	2000 kw.	Trolley circuit	25-cycles, 6-phase, 13,200 volt interpole	Westinghouse Elec. & Mfg. Co.
3	Transformers	Single-ph.	750 kw.	For rotary transformer	Oil insulated, self cooled, 13,200 to 380 volts	Westinghouse Elec. & Mfg. Co.
2	Condensers	Surface	20,000 sq.ft. cooling sur.	Main turbines	29-in. vacuum	Henry R. Worthington
2	Pumps	Centrifugal tri-rotor	26-in.	Circulating water	20,000 gal. capacity, turbine driven, 1000 r.p.m.	Henry R. Worthington
2	Turbines	Two stage	280 hp.	Driving circ. pump	1000 r.p.m., 180-lb. steam	General Electric Co.
1	Crane	Traveling	5 ton	Hoisting screens	Electrically operated—600 volt, d.c.	Whiting Foundry Equipment Co.
1	Crane	Traveling	50 ton	Turbine room	3-motor operated—600 volt, d.c.	Whiting Foundry Equipment Co.
2	Pumps	Turbine, two-stage	4-in.	Hot well	Turbine driven, 1800 r.p.m.	Henry R. Worthington
2	Turbines	Single stage		Hot well pumps	1800 r.p.m., 180 lb. steam	Terry Steam Turbine Co.
2	Heaters	Open	5000 hp.	Boiler feed water	Auxiliary exhaust	Harrison Safety Boiler Works
2	Pumps	Comp. duplex	9x14x8½x15 in.	Tank service	Non-condensing	Henry R. Worthington
2	Pumps	Four-stage	4-in.	Boiler feed	3000 r.p.m., 15 ft. head suction	Jeanesville Iron Works
2	Pumps	Air	12x31x18 in.	With condenser	28½ to 29 in. vacuum	Laidlaw-Dunn-Gordon Co.
2	Turbines	Horizontal	50 hp.	Driving boiler feed pumps	180 lb. steam, 3000 r.p.m.	General Electric Co.
1	Tank	Steel	35,000 gal. cap.	Make-up and gen. utility water	Head on heaters and for house service and gland water	Henry Vogt Machine Co.
1	Pump	Duplex	20x12x15-in.	Boiler feed, house or fire	Can be used for station service	Henry R. Worthington
8	Boilers	Water tube	567 hp.	Steam generator	200 lb. pressure, 125 deg. superheat	Babcock & Wilcox
8	Superheaters	Babcock & Wilcox	125°	Superheating steam	125 deg.	Babcock & Wilcox
1	Chimney	Brick, red radial	255 ft. high, inside dia. 13 ft.	Flue gases	Natural draft	H. R. Heinicke
2	Elevators	Platform	6000 lb. cap.	Elevating bunker coal	Motor operated	Abell Elevator Co.
1	Motor	Direct current	30 hp.	Elevator service	Direct current, 550 volts	Westinghouse Elec. & Mfg. Co.
1	Motor	Air current	30 hp.	Elevator service	Three-phase, 25-cycle, 440 volt	Westinghouse Elec. & Mfg. Co.
Pipe covering		Magnesia and asbestos	Various	Piping		H. W. Johns-Manville Co.

Two 4-in., four-stage boiler-feed pumps, each driven by a 50-hp. steam turbine, are placed in the 12-ft. high bay formed by the projection of the boiler-room floor and under the two 5000-hp. feed-water heaters, as shown at the right of Fig. 2. This arrangement gives a head for the boiler-feed pump of about 15 ft. as the heaters are supported 3 ft. above the boiler-room floor.

A 20 and 12 by 15-in. duplex reciprocating pump in the pump pit between the future Nos. 3 and 4 turbine units is so piped that it may be used for boiler feed, for house service, or for 300-lb. pressure fire service. The suction connects with the two concrete water intakes. All pump suctions are so piped that they may take water from the city mains if necessary.

In the bay formed under the boiler-room floor are two dry-vacuum pumps of the single, horizontal center-crank, double-flywheel type, equipped with Meyers steam valve-gear and Cincinnati air-valve gear.

Ammonia Pipe Fittings

By Gilbert Crawford, Jr.

SYNOPSIS—Describes the chief types of ammonia fittings in general use. Tells how to connect them and what troubles to expect when using the different kinds.

To the novice in a refrigerating plant, the ammonia-pipe fittings are a puzzle to be solved only after considerable study. The confusion is caused by the many types of fittings used in different plants, and sometimes in different parts of the same plant. Some of the types

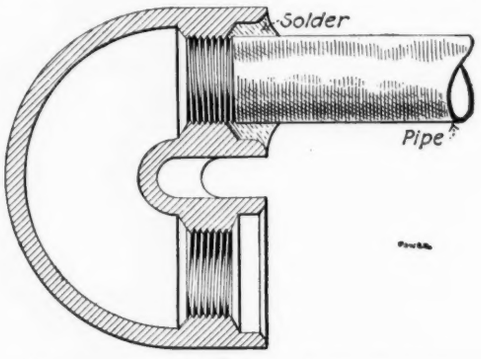


Fig. 1. Return Bend; Note Solder

outwardly resemble each other, but are not constructed alike.

There is no standard type of ammonia-pipe joint, and unfortunately, the fittings from the different manufactures, even though of the same type, are not interchangeable. An effort is being made to accomplish a standardization, but, on account of the great manufacturing outlay involved, it is doubtful if much can be done toward this end.

Ammonia under pressure is very penetrating, and in refrigerating apparatus particular pains must be taken to prevent leaks; they are not only disagreeable, but also expensive. Wherever a pipe screws into a fitting there is the possibility of a leak. This joint must be made tight, and in the flanged fitting, the joint between the flanges must be made tight as well. These are the two places where, in the ordinary plant, leaks may develop.

There are in wide use four general types of pipe fittings for ammonia work, as follows:

1. Screwed fittings.
2. Screwed fittings with gland.
3. Tongue-and-groove flanged fittings.
4. Boyle flanged fittings.

The first and third are used the more extensively, but the second and fourth have important applications. While there are other types on the market, they do not rank with these four in importance, though some are ingenious on paper.

Taking up the screwed fitting first, one sees (Fig. 1) that it is similar to the ordinary water- or steam-pipe fitting, but it is built on stronger lines and has a recess for solder. The joint between the pipe thread and the fitting thread is made tight in a variety of ways. The cheapest method is to cover the threads (especially the thread of the fitting, since the pressure is internal) with litharge and glycerin and screw the two together. This mixture, when proportioned properly, "sets" hard and the joint is satisfactory when well made. A much better method is as follows:

After screwing the pipe into the fitting to a hard grip, the fitting and pipe are heated at the joint, acid or soldering salts are applied, and the recess is filled with solder. Care must be taken that the solder sticks perfectly to both pipe and fitting, for on this depends the tightness of the joint. On this account the pipe is usually ground or filed bright, back of the thread, so that there will be no reason for the solder not adhering.

Another way of making a tight joint is to "sweat" the pipe into the fitting. This process consists in first tin-

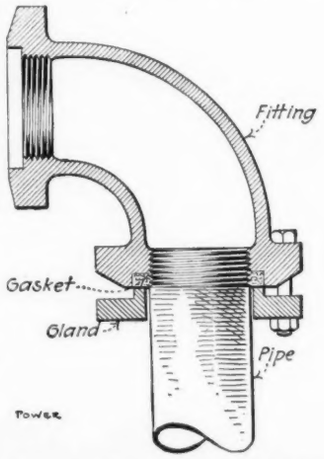


Fig. 2. Elbow with Loose Flange and Gasket

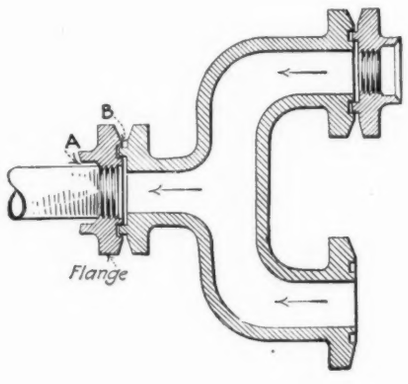


Fig. 3. Showing the Tongue and Groove Joints

ning the threads of the pipe and fitting and screwing the two together while hot, immediately filling the recess with molten solder. When properly made this joint is most satisfactory.

A word is not out of place here as to the material used in making screwed fittings for this class of service. As cast iron cannot readily be tinned, and as it is somewhat porous and brittle in comparison with other preferred metals, it is used but little for ammonia screwed fittings. Instead, malleable iron and semi-steel are used. Solder will adhere to them, and they are, especially the former, far more ductile than cast iron. For pipe couplings, wrought iron is sometimes used.

The screwed fitting with a gland is shown in Fig. 2. It differs from the plain screwed fitting in that the joint is made tight by a gasket. Instead of using a grommet or solder, usually a rubber gasket is placed in a recess of the fitting, and a gland, nearly always tightened by bolts, as in Fig. 2, holds the gasket in its place. The gland and the gasket act as a stuffing-box. When first put together, a solid ring gasket is used, and for renewals a split ring. The use of the latter saves unscrewing the pipe from the fitting. A leak in such a joint is easily stopped by drawing up on the bolts.

The standard type of tongue-and-groove fitting is shown in Fig. 3. This is a different fitting as it is flanged, and two points are to be made tight with it, at *A* and at *B*. The joint *A* is between the pipe and the flange and *B* is the joint between the flange and the fitting proper. The joint *A* may be made tight by the use of either solder or litharge. The joint at *B* is tightened by a washer set into the groove and held there by the tongue. The flange on the pipe is held against the flange of the fitting by bolts; the fittings are usually made tongue on one end and groove on the other. The washer is generally of lead or fiber, but may be of rubber in installations where there is vibration.

In Fig. 4 is shown a tongue-and-groove flange union. Two flanges, one tongued and one grooved, are bolted together, with a washer between. These flanges are sometimes made of drop-forged steel.

In laying out pipe lines using tongue-and-grooved fittings, it is customary to have the gas flow through the fitting from the groove to the tongue, where the choice is at will. This rule is sometimes excepted when the pipe line is vertical (the planes of the flanges horizontal) when the grooved flange is the lower of the two, to enable one to more easily place the washer in position.

The Boyle fitting (all ends tongued) is shown in Fig. 5. This type lies in the flanged class. The joints at *A* and at *B* are made tight with one gasket, usually of rubber. The gasket is placed in a recess formed by the flange and the end of the pipe, as shown. The tongue end of the fitting is held against the gasket by bolts connecting the pipe flange to the fitting flange, and by drawing up on the bolts, both joints are made tight. With the Boyle joint it is not necessary to have the pipe screwed tight into the flange; in fact, the flange is usually tapped with a uniform (nontaper) thread, which does not allow of a tight-screwed joint. Entire reliance against leakage is placed on the gasket.

There is also a sort of hybrid type of fitting, partly flange and partly screw, an example of which is shown in Fig. 6. Such fittings are useful for many purposes.

A comparison of the different fittings is difficult. Each has its advantages, each its disadvantages, and individual preference enters, as in all such cases.

The screwed fitting is the cheapest, is the lighter, and requires less machining, but a pipe line made up exclusively of screwed fittings is a poor affair. A leak cannot be repaired or an alteration made without perhaps taking down half the line, and the entire line must be made up on the job, which makes the soldering of the joints impracticable.

The screwed fitting with glands makes a tight joint, and is applicable on long pipe lines, such as street mains, where the gland is used as an extra precaution; entire dependence is not placed on the screwed joint. It will be noticed that the gland type allows of a certain amount of flexibility, sharing this distinction with the Boyle fitting, in that it can be turned somewhat on the pipe, even with pressure therein, the rubber gasket maintaining the joint. Like the plain screwed pipe line, a line made up of gland fittings exclusively cannot be taken down at any point. If a leak occurs at a joint, however, it can be stopped by tightening the gland.

The tongue-and-groove fitting admits of easy accessibility as the piping may be disconnected at any joint. The same may be said of the Boyle, although both are more expensive.

The Boyle flanged fitting has one disadvantage which about offsets its many good points. The pressure on the gasket created by the tightening bolts will cause the rubber of the gasket to creep slowly past the pipe thread on the end of the pipe, into the pipe system; this causes accumulations and stoppages. On the hot gas lines, the

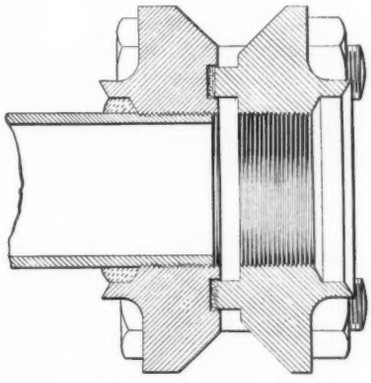


FIG. 4

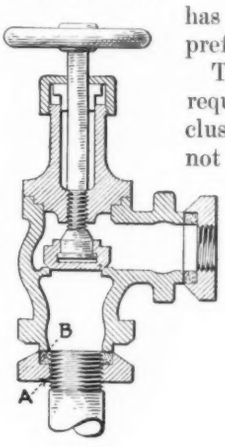


FIG. 5

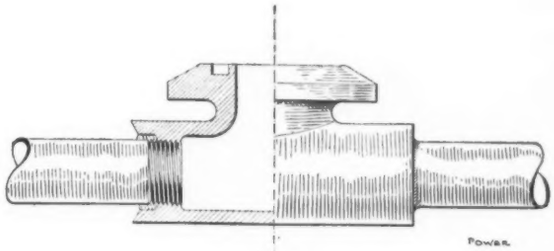


FIG. 6

SECTIONAL VIEWS OF AMMONIA FITTINGS; NOTE CHARACTER OF JOINTS

heat and pressure decompose and soften the rubber, and blowouts occur.

Where rubber is used as a gasket, it is occasionally necessary to "follow up" on the bolts to stop leaks. It is, therefore, questionable practice to place rubber-packed joints in places where leaks are hard to detect, such as freezing tanks, submerged condensers, etc.

To take advantage of the lower cost of screw-end fittings and yet have a simple pipe line to construct or change—one that may be largely made up in the shop—it is sometimes customary to use screw-end fittings with occasional flanged fittings. When pipe lines are thoughtfully laid out according to this combination system, the results are most satisfactory.

It is well to mention that the welding processes have found one of the many applications to the field of ammonia-pipe work. First-class headers and branches are constructed by their application, at a fraction of the cost if made up with fittings. The joints are eliminated and the whole job is neater and lighter.

A Heating Boiler Explosion

The energy and capacity for doing damage lurking in a domesticated and harmless-looking cast-iron boiler is underestimated by most of those who have to do with them. The effect of the explosion of a cast-iron boiler is shown by the photographs reproduced. This accident occurred in St. John's Church, Des Moines, Iowa, on Mar. 2 at 11 o'clock at night. "The loss," a member of the council states, "will be from $10,000 to $12,000, with no insurance, but we are thankful that no one was killed or seriously injured." The attendant had left the building about an hour before.

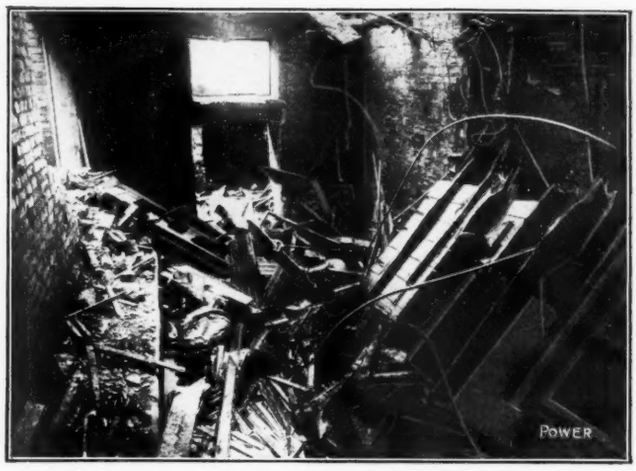


FIG. 2. VIEW IN THE BOILER ROOM

From the reports at hand, it appears that the boilers had not been behaving properly all winter and it is likely that an intelligent inspection would have revealed the fault, which might then have been remedied and the accident averted. The exterior view of the church, Fig. 1, shows the high windows damaged, which indicates the force and far-reaching effect. Fig. 3 shows a brick wall

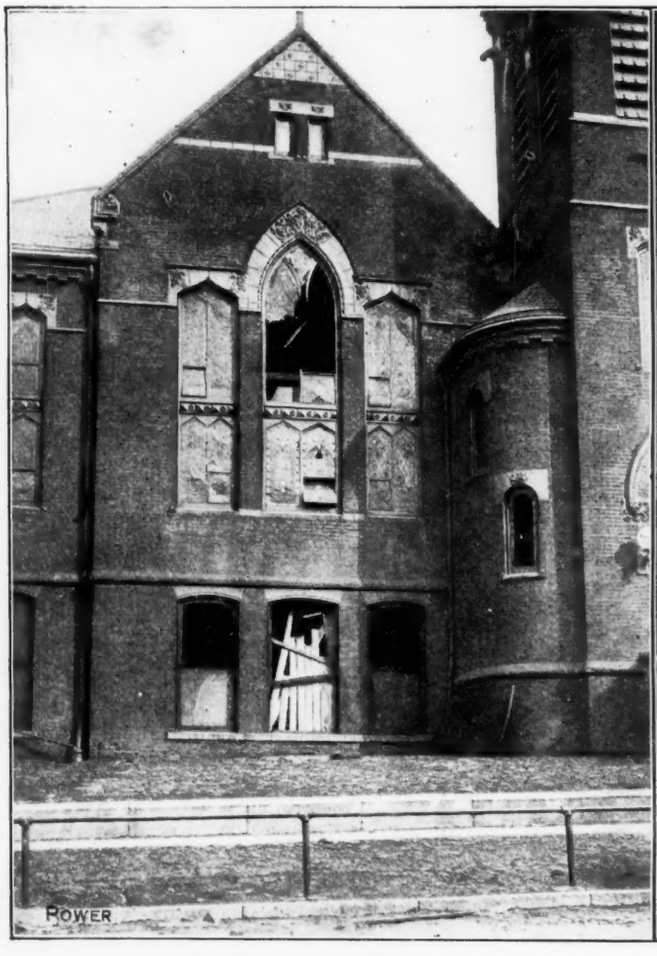


FIG. 1. HOW WINDOWS WERE BROKEN

FIG. 3. ANOTHER EXTERIOR VIEW

demolished. Fig. 2 shows the boiler room. As a whole, the damage seems entirely out of proportion to the size and pressure usually carried on boilers of this class. That there are frequent faulty installations of domestic heaters is well known. That it is international is shown in a British Board of Trade report, from which we quote the following regarding a somewhat similar accident.

The explosion was caused by over-pressure of steam, due to over-firing, there being no adequate means of relieving the boiler of such pressure.

We think the owners are responsible for the following reasons: (1) No safety valve, or other sufficient means were provided for relieving the boiler of steam pressure. (2) The management of the heating apparatus was not intrusted to a person with sufficient experience, and no printed or written rules were supplied to him. (3) The boiler was not periodically or at all inspected, as it should have been, by a qualified person. (4) No proper measures were taken by the owners to insure that the boiler was worked under safe conditions.

The firm described as "ironmongers, plumbers and sanitary engineers," we think is partly to blame for the explosion, as no sufficient means were provided for relieving the boiler of steam pressure. Further, we think that the duty of those who install boilers is to take all precautions to prevent persons being injured by explosions. This being their duty, it is no answer to say the explosion would not have happened if the boiler had not been over-fired.

Boiler explosions are nearly always due to preventable causes, and there was certainly no unavoidable cause in this case. We think the explosion would have been averted by reasonable precautions and by the exercise of ordinary care in the installation, inspection and supervision of the boiler. This is not the first explosion, of the boiler of a heating apparatus having no safety valve, which has been attended by loss of life.

Evaporative Tests with Oil as Fuel

By Charles Jablow

SYNOPSIS—Evaporative efficiency of different oils after deducting steam for atomizing.

During the past few years tests have been conducted by the engineering division of the Oklahoma Agricultural and Mechanical College to determine the economic use of some of the grades of coal and oil which are available in this vicinity. Some recent investigations have been carried on to obtain a comparison of different oils when used as a fuel under a 200-hp. B. & W. boiler equipped with a Peabody oil furnace. The comparison was to determine the evaporative efficiency of the different oils, when the amounts of steam for atomizing were taken into account. This consideration gives rise to the two terms, which will be used later, "gross and net boiler efficiency." The gross efficiency is represented by the quotient obtained by dividing the heat given up to the feed water per pound of oil, by the total heat contained in one pound of the fuel. To obtain net efficiency the amount of steam required for atomizing is subtracted from the amount evaporated before making the above division.

In the usual system of burning oil under a boiler, the burner is at the front and the flame is directed against the brickwork at the bridge-wall. This is to prevent any excessive local heating of the tubes or boiler shell. In the system under discussion the burner is located at the bridge-wall, which is about half the length of the setting from the front. The flame is directed toward the front of the setting. By this method there is no excessive local heating and the flame is not permitted to come in contact with the outer walls of the setting or exposed metal of the boiler. It also provides a sufficiently long travel for the gases so as to insure complete combustion. The boiler used in this test has been installed within the last few months and was perfectly clean and tight. The fittings were also all new.

To insure the greatest accuracy the meters that were used on the oil- and feed-water lines were carefully calibrated before placing in the line. A separate boiler was used to supply steam for the burners and the required amount of water to keep a constant level in the gage-glass of this second boiler was recorded. An individual tank, pump and oil line, was used so that the oil under test should not become mixed with that used in the plant, as the latter supply was drawn from the large supply tank, which is a mixture of various oils added from time to time. The tank used for the test had a capacity of 425 gal., a sufficient amount to cover the period of any one test.

Before the test tank was filled, oil was permitted to flow from the tank car for several hours so that the line to the siding should be well cleaned of other oil and that a nearer average sample could be collected. Another precaution in the test was to proportion the air admitted so that no smoke should be perceptible and still not allow an excess of air. The results of the tests are tabulated in the accompanying table.

Results of Tests

	Crude	Fuel
Average duration of tests, hr.	3.5	4.125
DIMENSIONS		
Grate area, sq.ft.	60	60
Heating surface, sq.ft.	1870	1870
Area smoke stack at top, sq.ft.	23.8	23.8
Height of stack, ft.	125	125
Ratio heating to grate surface	31.2	31.2
PRESSURES		
Steam pressure, gage, lb.	112	101.7
Draft in breeching, in. of water	0.109	0.128
TEMPERATURES		
Boiler room, deg. F.	76.5	77.5
Feed water, deg. F.	145	165
Flue gases, deg. F.	352	307.5
Oil to burners, deg. F.	75.2	153
FUEL		
Total weight of oil fired, lb.	1783.8	1560.3
Heating value per lb., B.t.u.	22,115	18,652.5
Specific gravity at av. temp. 78 deg.	0.808	
Specific gravity at av. temp. 81 deg.		0.877
Degrees Baumé at above temperatures	44	30
Fuel burned per hour, lb.	509.7	378.3
WATER		
Total weight fed to boiler, lb.	25,974	22,046.5
Weight fed to auxiliary boiler for steam to burners, lb.	780	1255
Per cent. of total steam generated used to atomize oil	3.1	5.91
Water per hr., lb.	7421	5344.6
EVAPORATION CORRECTED FOR QUALITY		
Quality of steam, per cent	96.8	96.3
Total weight evaporated from feed water temperature, lb.	25,150	21,230
Total equivalent evaporation, lb.	28,000	23,140
Factor of evaporation	1.112	1.089
Equivalent evaporation per hr., per sq.ft. heating surface, lb.	4.28	3.00
Equivalent evaporation per hr., lb.	8000	5610
Actual evaporation per lb. of oil from feed temperature, lb.	14.09	13.61
Equivalent evaporation per lb. of oil, lb.	15.65	14.83
HORSEPOWER		
Horsepower developed	231.9	162.61
Builders' rating	200	200
Per cent. of rated horsepower developed	116	81.3
EFFICIENCY		
Boiler efficiency not accounting for steam used in atomizing, per cent	68.6	77.1
Boiler efficiency accounting for steam used in atomizing, per cent	66.7	72.6

Too much weight should not be given to the equivalent evaporation per pound of oil without considering other factors at the same time. In the results attention might be directed to the amounts of steam used in atomizing and the effect this has on the net efficiency of the boiler.

The average cost at the storage tanks of the oil companies, for the crude oil was 98c. per barrel of 42 gal. For the fuel oil the average cost was 82c. In a study of the tabulated results, it will be seen that while the use of the fuel oil is more economical, the difference is not as great as is represented by the costs per barrel. If the above test had been made in colder weather, the results would probably show slightly more favorable to the use of crude oil on account of the steam used in atomizing.

On account of the fact that enough attention is not given to the amount of steam used in spraying oil in oil burners under boilers, the following is included. It is not alone the cost of water, for this may not be a considerable item, but when the cost of evaporating this water into steam is considered, methods of oil burning may receive closer attention.

Figuring on a basis of an equivalent evaporation of 15 lb. of water per pound of oil and 5 per cent. of the steam generated to be used for atomizing; one pound of oil would be expended in atomizing, for each 300 lb. of steam generated from and at 212 deg. F. For other values substitution can be made in the equation:

$$X = \frac{100\ E}{A}$$

where

X = Evaporation from and at 212 deg.;
E = Equivalent evaporation per pound of oil;
A = Per cent. of X used for atomizing oil.

For the example taken above the cost of atomizing, when developing 100 hp.

$$100 \times 34.5 = 3450\ lb.$$

of steam are evaporated and this would require for atomizing

$$3450 \div 300 = 11.5\ lb.\ of\ oil$$

The above formula can be modified to give results in pounds of oil used for atomizing per horsepower developed, if the boiler performance and the amount of steam used for atomizing are known. The equation would read

$$O = \frac{34.5\ A}{100\ E}$$

where O = pounds of oil used for atomizing for each horsepower developed.

Locomotives for Panama Canal

The photograph shows one of the 40 electric locomotives which the General Electric Co. is building for the U. S. Government to be used in towing ships through the Panama Canal locks. Each machine weighs 82,500 lb. and has a tractive effort of 47,500 lb. This power is derived through two 75-hp., three-phase, 25-cycle, 220-volt, mill-type motors, one connected to each axle through gearing.

The locomotive is propelled by means of a rack rail while towing and while going up and down the steep grades from one lock level to another at a speed of two miles per hour. When running light on the return tracks, the speed is changed to five miles per hour, the rack pinion being entirely released and the locomotive proceeding by ordinary traction methods.

Towing Locomotive for Panama Canal

Reference to the photograph will show a vertical windlass and drum at the center of the locomotive; this carries 800 ft. of 1-in. steel hawser for towing. Ordinarily four locomotives will be required to put a ship through a lock; two on each side, the forward pair pulling and the astern pair guiding the ship. With very large vessels it may be necessary to employ six locomotives.

Sarco Room-Temperature Regulator and Mixing Valve

A temperature regulator, based on the use of liquid expansion operating an elongated corrugated diaphragm,

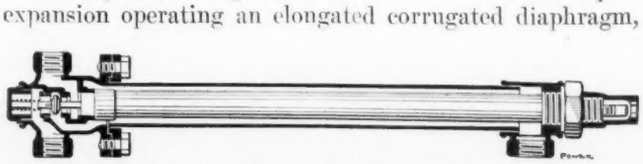


Fig. 1. Sarco Mixing Valve

is being placed on the market by the Sarco Engineering Co., 116 Broad St., New York City.

The room-temperature regulator, Fig. 2, is substantially of three parts: The thermostat, which is mounted on a board and exposed to the atmosphere, the temperature of which it is desired to control; the controller and the valve.

The thermostat is practically a cylinder containing a heavy oil, the capacity of which is varied by regulating the extension of a corrugated tube. When the temperature of the air rises, the liquid in the thermostat expands and produces a considerable pressure in the thermostat, which is transmitted by a fine copper tube to the controller, there compressing another corrugated tube, which when contracted, forces out a piston, tending to close the valve. When the temperature falls, the process is reversed and the valve is opened, thus regulating the supply of steam or hot water used to maintain the temperature required. The regulator is self-contained and supplies its own motive power, without outside sources of energy.

Another device using the same principle is the Sarco mixing valve, Fig. 1, an apparatus which produces the continuous discharge of water at a constant temperature. This device is so constructed that hot water or steam is supplied at one side and cold water on the other. In the mixing chamber within the valve there is a cartridge which controls the size of the hot-water or steam inlet. The discharge water is thus maintained at a predetermined temperature, which, it is claimed, will not vary 1 deg. under ordinary conditions, hence any desired temperature may be obtained.

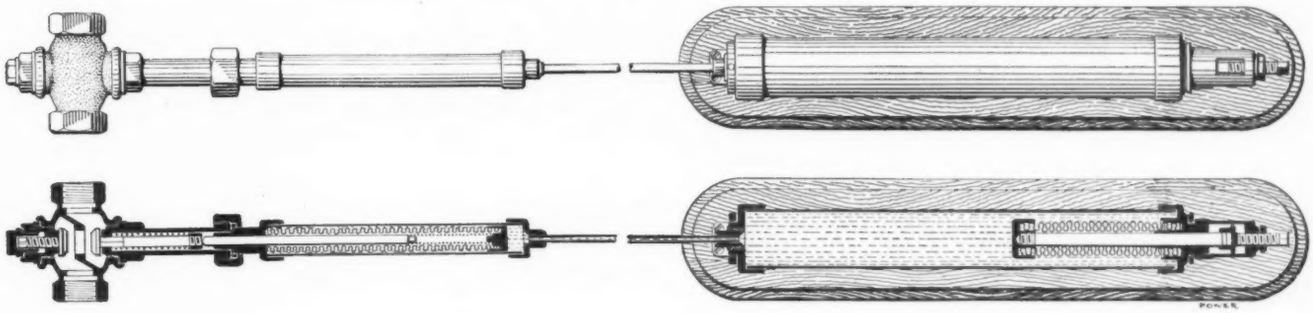


FIG. 2. SARCO ROOM TEMPERATURE REGULATOR

Purchasing Boilers--I

BY J. E. TERMAN

SYNOPSIS—If you were to purchase a steam boiler, would you know how to specify what features were to be incorporated in its design? Would you know what features are or are not desirable? This article gives a number of points, and the procedure to follow in purchasing boilers.

It is intended that this article will aid the purchaser of boilers who buys one or two at a time. The purchaser of many boilers can afford to hire a competent consulting engineer to look after his interest, if he has not already in his plant an engineer capable of handling the subject. When a consulting engineer is engaged, the purchaser should make certain that he is capable and then follow his advice implicitly.

If additional boilers are bought and added to an existing small plant, it is probably because the plant engineer, who may possibly have little theoretical steam-engineering knowledge, complained of the difficulty of maintaining the desirable steam pressure until the management finally decided to purchase additional boilers.

The complaint in practically all such cases is proper, for the engineer is in a position to know the difficulties of operation. It is also almost certain that remedying the conditions of which he complains will result in economy. However, it should be understood by the management that an apparent lack of boiler capacity is often remedied by means other than by the purchase of additional boilers.

DRAFT AND GRATE AREA

The fundamental feature of boiler-plant capacity is the ability to burn an amount of fuel sufficient to generate the steam required. This ability to burn fuel depends primarily on two things, draft and grate area, and both of these factors have to be adjusted according to the kind of fuel used. The question of grate area is usually, in a measure, cared for by the boiler manufacturer, but the stack capacity may be inadequate in a plant using one stack for all boilers, and where the boiler capacity has been increased since the initial installation. For instance, the original equipment may have consisted of two or three boilers and a stack capacity to barely suit their needs. Therefore, any addition to the boiler equipment would overload the stack. Often, under such conditions, the original boiler capacity has been doubled or trebled without any change in the stack capacity. In such aggravated cases the addition of a boiler will actually reduce the plant capacity.

The owner who contemplates purchasing additional boilers should satisfy himself that his apparently insufficient boiler capacity is not due to lack of chimney capacity, either as regards the intensity of draft or volume, or to lack of proper grate area.

With the finer grades of anthracite coal usually sold for power purposes, it is practically impossible to burn enough fuel with ordinary stack draft to operate a boiler at its normal capacity. However, there are many small plants burning this grade of fuel with natural draft, the

owners of which will add to the boiler equipment when needing more steam, without considering the use of artificial draft. The installation of a blower in such cases would often enable the burning of enough coal to operate the boilers efficiently and relieve the condition diagnosed as lack of boiler capacity.

Another feature that should be determined before purchasing additional boiler equipment, is whether the steam generated by the boilers on hand is economically used or not. In plants using a single engine and where no steam is used for heating coils, etc., determining the efficiency of the use of the steam is relatively simple. Tracing its efficient use is more difficult with engines scattered about the plant, large radiation losses, and steam used for other than power purposes.

Are Additional Boilers Required?

The best method to pursue when contemplating the purchase of additional equipment, even for the small plant, is to have a reliable consulting engineer look into the plant conditions to determine if additional boilers are actually required, or if changes in operation cannot be made which will obviate the necessity for new boilers.

While this course may seem expensive in the average case, the chances are that an investigation will reveal conditions which will, when rectified, result in enough saving in future operation to pay a handsome profit on the engineer's fee, even if additional boiler equipment is required.

The consulting engineer may show that more boilers are not necessary, in which event, their cost and the interest on the investment are saved, in addition to the economy gained by the changed operating conditions that rendered new boilers unnecessary.

If, on account of any of the numerous reasons which deter the management from employing a consulting engineer, it is decided to take chances and settle the question unaided, the following suggestions may be of service in deciding the question of purchasing additional boilers: First, find out how much heating surface in square feet is contained in the boilers already installed, which need not be done with extreme accuracy. If the boilers are of the horizontal tubular type, the calculations may be made as follows:

To find the heating surface of each boiler, add the combined diameters of all tubes, in feet, to one-half the diameter of the boiler shell in feet, and with their sum as a diameter find the circumference of the corresponding circle. Multiplying this circumference by the length of the tubes in feet will give the heating surface in square feet.

For example, a 72-in. boiler, 18 ft. long, contains 70 four-inch tubes. The combined diameter of the tubes is

$$\frac{70 \times 4}{12} = 23.3 \; ft.$$

One-half the diameter of the shell is 3 ft., then the total diameter is 3 + 23.3, or 26.3 ft. The circumference of 26.3 diameter is 82 ft., and 82 × 18 is 1476 sq.ft. of heating surface.

If bituminous fuel is used, every foot of the heating surface should evaporate from 3.8 to 4 lb. of water per hour, when forced, and if the maximum, not average, rate at which steam is required does not equal or exceed this amount, some other cause of deficient steam supply should be looked for.

Grate Area and Heating Surface

Under average conditions in the small plant, ½ lb. of coal should be burned per square foot of heating surface per hour to evaporate, say, 4 lb. of water into steam. If it is found that this amount of coal cannot be burned, the draft conditions should be investigated or the available grate surface be looked after. With ordinary chimney draft, it is usually difficult to burn good bituminous coal at a rate higher than 20 to 25 lb. per sq.ft. of grate surface per hour; 20 is fairly easy to obtain, but 25 lb. are generally difficult.

If the proportion of the grate to the heating surface is such that much over 20 lb. of fuel are burned per square foot of grate per hour to get the maximum results from the heating surface, then the grate surface requires enlarging. If the rate of coal required to be burned per square foot of grate surface per hour is not over 20 lb. to give the maximum capacity for the heating surface available, as already estimated, and the pounds of steam required per hour, divided by the number of square feet of heating surface, is not over four, then the draft conditions should be investigated.

It must be understood that the foregoing are about the maximum rates under average conditions in the small plant and can be used as a guide to tell whether there is some glaring deficiency in the available heating surface or grate surface in an existing plant.

Measuring Draft

A good grade of bituminous coal in a plant with average surroundings requires a stack from 100 to 125 ft. high to afford ample draft. A cross-sectional stack area of about 4 sq.ft. for the first 1000 sq.ft. of heating surface and 3 sq.ft. for each additional 1000 sq.ft. is required to give the proper volume of draft. The draft in inches of water, with a stack of the height and area as indicated, under operating conditions, should be about ⅝ to ¾ in. at the base of the stack and ⅜ to ½ in. in the furnace over the fire.

A plant may be provided with a stack of ample height and area and still be unable to burn the required amount of fuel, owing to improper connections, either as to shape or size, between the boilers and the stack. Therefore, the measurement of the effective draft over the firebed with the fire-doors closed and the damper and ashpit doors wide open is the real test of whether the draft conditions are proper for the grate surface. The measurement of the draft should be taken when all the boilers that the stack is supposed to serve are operating.

Type of Boilers To Be Selected

After deciding that new boilers are necessary, what size and type should be adopted? Since this article is only intended to cover the average case for the small plant, the type of boiler could be eliminated and it be assumed that the horizontal, return-tubular boiler would be used. However, some of the general features of a few other types will be discussed.

The water-tube boiler is made in so many forms that it is difficult to say much, in a general way, about them. They are capable of carrying a high steam pressure, and if pressure above 150 lb. is desired, the water-tube or

the vertical tubular boiler would be used, in most cases.

If a water-tube boiler is to be used, select a simple design. The average purchaser should pay no attention to high-brow theories in regard to circulation and efficiency; he should buy a boiler that is so designed that it can be repaired and cleaned without being torn down. There are, however, points connected with the proper design for efficient operation that are worthy of consideration, providing that accessibility has first been attained.

Few small plants will be interested in the water-tube boiler, because the first cost is approximately 50 per cent. above that of the return-tubular and its maintenance requires more skill and costs more. The life of such boilers is usually much shorter than that of the horizontal tubular type.

The vertical tubular boiler, particularly in sizes of 150 to 250 hp., is an excellent one for power purposes, being low in first cost, slightly under the horizontal tubular, and is economical to operate. It does away with brick-setting repairs, and is capable of being built for high pressures. This type, however, has one serious drawback, which is that the crown-sheet is extremely sensitive, and unless the feed water is of the best quality for boiler purposes, this type should not be considered.

The locomotive type is sometimes used in small plants, but little can be said in its favor. It is high in first cost, fairly efficient, extremely costly to repair, a repair of any magnitude in the firebox costing practically as much as the boiler; it has some advantage where head room is limited, or where the location of the boiler is considered temporary.

The horizontal tubular boiler is the type most frequently used in the small plant, and has the most advantages under general operating conditions. It is easily cleaned and repaired; it requires the least skilled attention of practically any boiler, and it is about equal in efficiency to any when boilers of equal capacity are compared.

A feature that should be considered in purchasing boilers to add to an existing plant is that the men have become accustomed to the type already in use, and if the boilers have given satisfactory service there should be some good reason for making a change. It will be assumed, therefore, that the horizontal return-tubular boiler is to be adopted and the rest of this article will refer to that type.

Size of Unit to Be Adopted

The size of unit to be adopted depends largely upon the plant conditions. If it is at all practicable, every plant should consist of a minimum number of two boilers.

Generally, the larger the boiler the more economical its operation and, if the size of the plant will stand three or more large units, boilers of 78-in. diameter and 18-ft. length are a good size to adopt. This size represents about the maximum capacity for the type, and, although much larger sizes are built, it is doubtful if they have demonstrated their worth.

The diameter of this type is limited by the thickness of the sheet necessary to use for the pressure desired. It has been demonstrated by trial that a ⅝-in. sheet is practically the limit for externally fired boilers, and even this thickness is too great, except where good feed water is used and the best workmanship employed. Boilers are occasionally built with thicker sheets and the edges of the plate at the girth seams are planed or milled down, but it is doubtful if this construction is justified, and it remains to be proved that it represents good practice.

Some Common Transformer Connections

By Norman G. Meade

Among the advantages of alternating-current distribution is the facility with which the potential, current and phases can be changed by different combinations of transformers. For single-phase work, transformers can be connected so as to change any current and voltage to any other current and voltage within practical limits. In a multiphase system, in addition to these changes, the phases can be changed to almost any form desired.

The common methods of connecting transformers to single-phase, constant-potential mains are shown in Fig. 1. Practically all distributing transformers have primary and secondary windings made up of two coils each, to secure a flexibility of voltage combinations. Either the primary or the secondary coils, or both, may be connected in series or in multiple. At *A*, in Fig. 1, the primary coils are connected in series and the secondary coils in multiple to secure a 2200-volt to 55-volt transformation. At *B* both the primary and the secondary coils are connected in series for a 20-to-1 transformation. For residence lighting, the most economical method of supply is through single-phase transformers with three-wire secondaries. A tap is brought out from the middle of the secondary winding which is connected to the neutral wire of the three-wire system. In this way a few large transformers can be connected by three-wire secondaries in a residence or other district and will take care of a large number of connected lamps. Such an arrangement of transformer connections is shown in Fig. 2.

A modification of the three-wire system is shown in Fig. 3, in which the outside wires of the secondary system are fed by a single transformer and the neutral wire is taken care of by a balancing transformer connected at or near the center of distribution. The effect of the balancing transformer is similar to a motor-generator balancing set—that is, the voltage of the heavily loaded side of the three-wire system is boosted to compensate for the excessive voltage drop on that side, owing to the unbalanced load conditions. The capacity of the balancing transformer need be only half the greatest variation in load between the two sides of the system.

Where the ratio of transformation is not greater than 2 to 1, auto-transformers can be used to advantage in place of the regular transformers. In effect, these are the same as balancing coils. In Fig. 4, *A* shows a three-wire secondary or distribution system fed from a 220-volt main and so arranged as to give a potential of 110

volts between the neutral wire and the outside wires. At *B* the secondary system is essentially the same, but the primary main has a potential of only 110 volts, the auto-transformer in effect giving the same result that would be secured if an ordinary transformer having a 110-volt primary and a 220-volt secondary were used.

The plain two-phase or quarter-phase connection shown in Fig. 5 is simply two single-phase transformers connected to their respective phases, the phases being kept entirely separate. In three-wire, quarter-phase work one of the secondary leads can be used as a common return, as in Fig. 6.

The three-phase connections shown in Fig. 7 are known as delta connections and are of advantage where continuity of service is important. The removal of any one transformer does not interrupt three-phase distribution and the removal of two transformers still admits of power transmission on a single-phase of the circuit. Where one transformer is removed, however, each of the two remaining ones must carry 1.73 times the original current for the same load and the internal losses in this case will be greater.

The *Y* or star connection shown in Fig. 8 has one of the terminals of each primary and each secondary brought to a common connection, the remaining three terminals being connected, respectively, with the supply and the

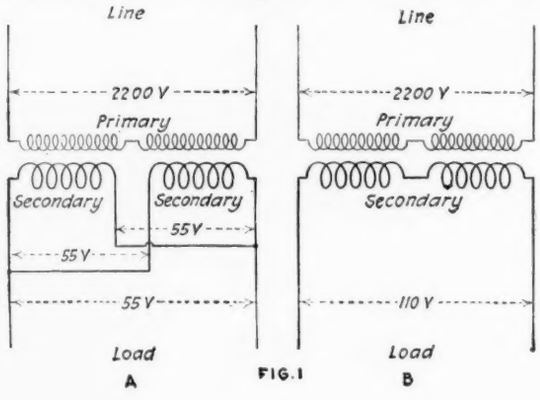


FIG. 1

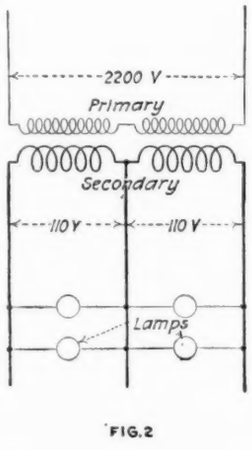


FIG. 2

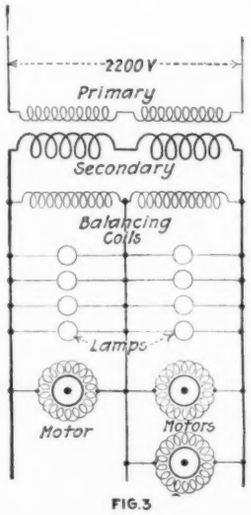


FIG. 3

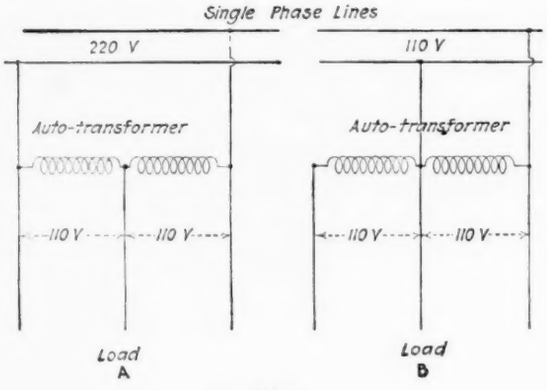


FIG. 4

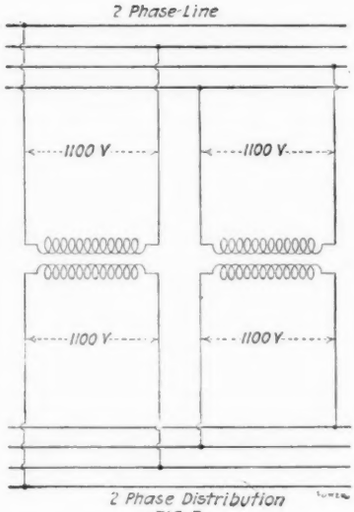


FIG. 5

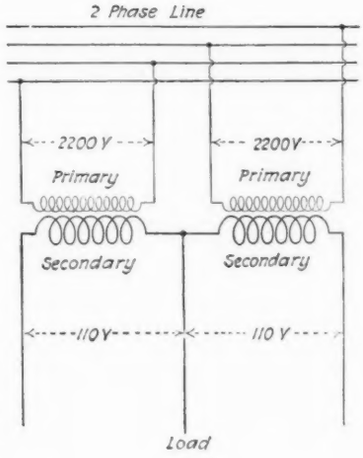


FIG. 6

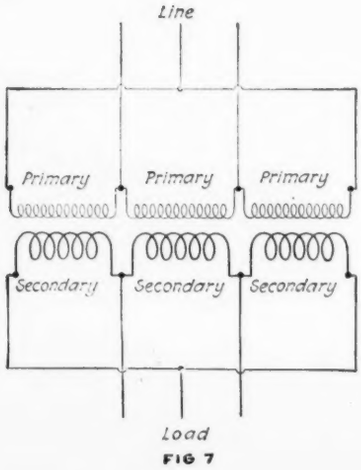


FIG 7

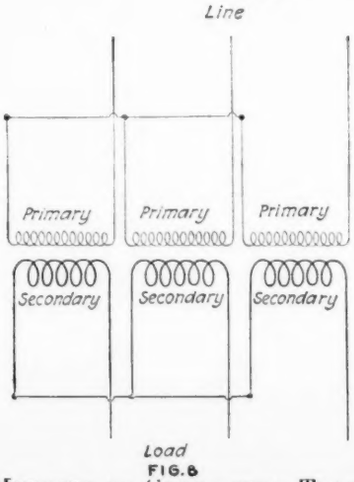


FIG. 8

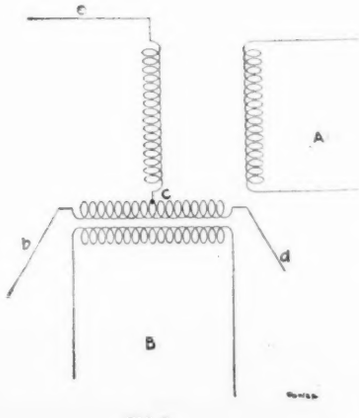


FIG 9

VARIOUS METHODS OF CONNECTING TRANSFORMERS

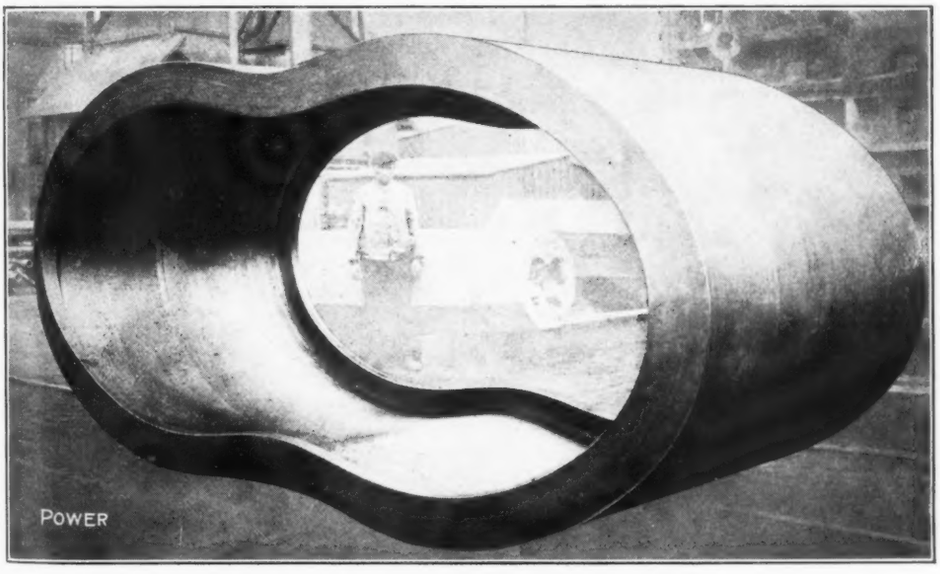
distribution system. An advantage of this connection over the delta is that for the same transmission voltage each transformer is wound for only 58 per cent. of the line voltage.

Two currents differing in phase by 90 deg. may be transformed into three-phase currents differing by 120 deg., or *vice versa,* by using the combination shown in Fig. 9 and well known as the "Scott" connection. Two transformers, *A* and *B,* are connected to two-phase mains. The secondary coil of *B* is represented by *bd* and that of *A* by *ec*. The secondary coil of *A*—that is, *ec*—has 0.866 times as many turns as the secondary of *B* or, what amounts to the same thing, an 86.6 per cent. voltage tap is brought out from the secondary of *A,* to which the lead is connected The other end of the secondary of *A* is connected to a tap brought out from the middle point of the secondary of *B*. Therefore, the leads *bde* form a three-phase system, or if three-phase currents are applied, they will be transformed to two currents differing in phase by 90 deg. in the primary windings of *A* and *B*.

Turbine Casing Deformed

The photograph shows part of a casing for a large marine turbine. Originally, of course, the casing was cylindrical.

This casing is of German manufacture, the metal being supplied by a company other than the builders. The



Large Turbine Casing Deformed

deformation test was made to demonstrate to the builders the quality of metal supplied. Although American engineers will perhaps question the merits of such a test, it is interesting as an example of the German's effort to be thorough.

Smoke Abatement in England

The progress of the movement for smoke abatement and fuel economy in Great Britain during the past 12 months, writes Consul-General John L. Griffiths, has taken the form chiefly of propaganda education and pioneer work in respect to improved methods of burning coal, for both factory and domestic purposes. In addition, steps are being taken to secure accurate measurements of atmospheric pollution. Fifteen of the largest cities have agreed to join in these experiments, and in London the work commenced in November last and is at present in operation. Owing to delay in securing the necessary soot and dust gages, the start in this work in all the 15 cities has had to be deferred until this spring. It is not expected that the comparative records will be available before the close of this year.

The cities which will undertake these observations are Birmingham, Bradford, Crewe, Exeter, Glasgow, Hull, Leeds, Leicester, Liverpool, Malvern, Manchester, Newcastle, Plymouth and York, in addition to certain London boroughs.

A bill has been drawn for introduction into Parliament to consolidate existing laws, as well as to provide local authorities with extended powers against the emission of black smoke. This is a private bill—that is to say, not a government measure—and as the supporters were not successful in the ballot for private members' bills, nothing will probably result this year, but the existence of the bill has created increased interest among smoke reformers, particularly as to the lines of future legislation.

The educational classes for engineers and firemen, started in several cities, continue to meet with growing success. The object is to develop properly trained bodies of skilled firemen, who, it is claimed, are essential to the solution of the black-smoke problem. The classes in Glasgow, which have been very successful, are carried on during the winter months at different populous centers, and are under the direction of smoke inspectors of the municipality. Each winter 100 to 200 firemen have been enrolled since the classes were inaugurated four years ago, and it is now proposed to start more advanced classes.

In connection with the subject of smoke abatement should be noted the greatly increased use of gas and electricity for domestic purposes. This is particularly the case in London and in provincial towns where gas is cheaper than coal. The rapid growth in this direction is so marked that it is believed by many that gas and electrical appliances will, to a great extent in the near future, take the place of coal grates and fires, and that those who prefer coal fires will use smoke-consuming grates or employ smokeless-coal substitutes.

While progress is constantly being made, it is necessarily slow because of the limited powers conferred by existing laws and the fact that societies for the suppression of coal smoke are dependent upon membership fees and donations for the funds required to carry on their work.

Accident to Ammonia Compressor

One man was killed and three injured, one of them very seriously, when the rear head of the ammonia cylinder was knocked from a refrigerating machine in the Hough Ave. plant of the Cleveland & Sandusky Brewing Co., Cleveland, Ohio. The wrecked machine was of 100 tons refrigerating capacity.

The accident occurred while the machine was being started up at 12:15 p.m., after a short shutdown. Chief Engineer James D. Bowman, at the throttle of the steam end, was struck by one of the flying pieces and so badly injured that he was suffocated before assistance could reach him. George Kilburn, assistant engineer, standing by the ammonia cylinder, had his right leg broken, but managed to get to a window and partly through it before he was overcome. More than one-half of the rear head of the ammonia cylinder, carrying the valve chests with it, gave way. The low-pressure ammonia line was broken in the tee connecting with the inlet valves, while the high-pressure line, which connected with the two lower valve chests by a tee below the cylinder, was carried away at the ceiling and thrown over the ammonia end, falling across the steam end, where it bent the governor and Corliss valve reach rods. The handwheel on the steam-throttle valve was bent over and one of the dashpot reach rods broken. Fig. 1 shows the compressor.

Fig. 2 shows the end of the ammonia cylinder and the line of the break. This cylinder consists of a spool-shaped casting which is bolted to a yoke-shaped seat on the bedplate by a longitudinal flange on its lower side. The cylinder heads are secured to the cylinder flange by heavy stud-bolts, none of which was broken. This figure shows a portion of the cylinder head still in position. The break passed through two of the bolt holes and one of the

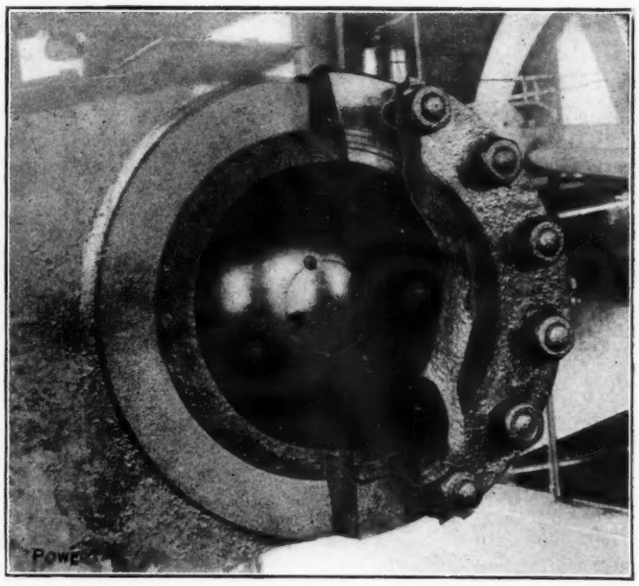


FIG. 2. DAMAGED AMMONIA-COMPRESSOR HEAD

valve chambers. On the left-hand side the cylinder flange was entirely carried away for that portion of its circumference where it rested against the bedplate, the break starting at two diametrically opposite points of the flange and running around the wall of the cylinder.

There are no marks on the piston or the cylinder head to indicate that they had been in contact. The line of the break following the fillet of the cylinder flange would seem to indicate that the stress had been thrown upon this portion of the rear flange by something between the front head and the piston sufficient to fill the clearance space of the machine. As the front head was still in place with its valve bonnets when the photographs were taken, this was impossible to verify.

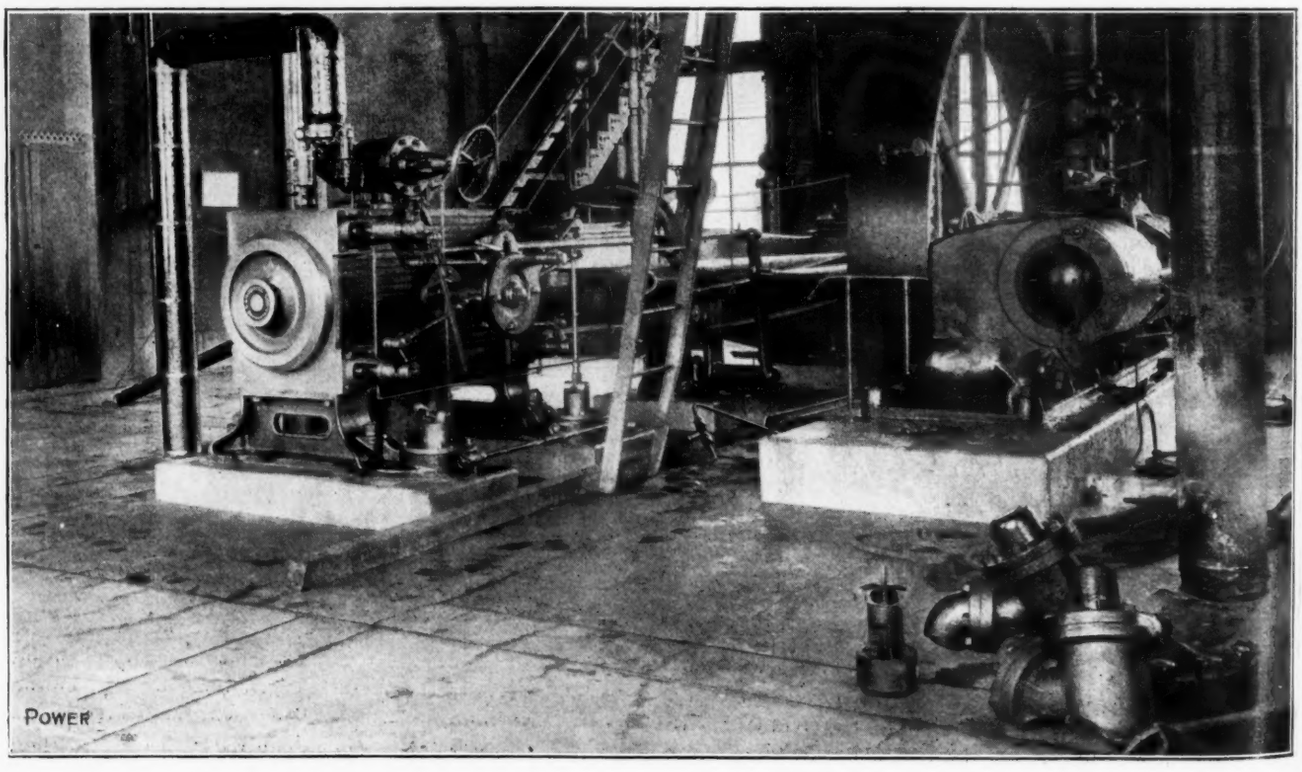


FIG. 1. THE DAMAGED COMPRESSOR, BROKEN PARTS IN FOREGROUND

How a Fireman Made Good

There was no hotter boiler room in Chicago that August afternoon. The ceiling was low, the boiler load was heavy and the rest periods were few and far between. But steam had to be kept up and the gage needle pointing to the 150-lb. mark, or the chief engineer would want to know why.

What if it was hot in the boiler room, the refrigerating machine had to run, and the men sitting at their roll-top desks in the offices above, demanded the comforts of washed air and of the electric fan.

Tim Donovan was not concerned about these matters, his job was to keep up steam, and there was no time to worry about the troubles or comforts of others. Perspiring, begrimed with coal dust and wielding a coal scoop with vim was how the subscription man found Donovan. A short survey of the situation convinced the visitor that the time and place were not conducive to business. As he watched the grilling work of Donovan, his sympathy for the man and his condition sent him away determined to help him if he could.

Now, Donovan was of a studious nature, which fact the subscription man had learned from the chief; why not send him a good work on engineering? He did so, with his compliments, and promptly forgot all about the matter.

Something like two years passed and the subscription man had forgotten Donovan; in fact, would not have known him on the street with the grime of the boiler room removed. As the "sub" man was walking up La Salle St., he received a vigorous thump on his back and a big, commanding hand gripped his own.

"Yer th' man I've been lookin' for," shouted Donovan, unconscious of the passing throng. "How are ye, me b'y!" which was emphasized with another thump on the back.

"Guess you got the wrong man," replied the subscription man, eyeing Donovan nervously, "I don't know you; I never saw you before."

"Not me, me b'y. Come and crook yer elbow, 'tis toime ye had one on me."

"But I don't know you; you have got the wrong man."

"I tell ye I've not. Listen, do ye moind th' day ye came int' me b'iler room about a year ago, and later on sint me a book on engineerin'? 'Twas th' beginnin' of me success. Before I had nothin' in me dome, now I've ivery thin' in the book, and some more. An', best of all, they can't take it away from me. Do ye see me stoyle, son? I can wear me kid gloves an' not neglect me job."

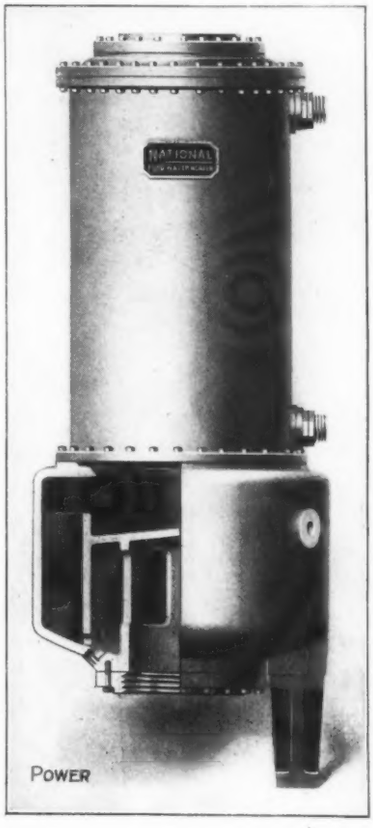
A light began to dawn on the subscription man's mind. Then he knew Donovan and recollected the position he formerly held. Filled with astonishment at the change he asked Donovan what position he now held and how he had procured it.

"Man, dear," replied Donovan, "I'm chief out here to R——. All I have to do, compared wid what I us'ter, is t' sit in me chair and tell th' min what t' do. I'm th' boss, me b'y. I give th' orders, and me days of sweatin' ferninst a sit of b'ilers be over. But yer th' b'y what started me roight wid yer little engineerin' book, and I don't forgit. Now will ye come along an' blow some suds?"

The subscription man later in the day joyously meandered up La Salle St., at peace with Donovan, himself and the world. A little help, and a fireman had fitted himself to occupy a chief engineer's position. He had made good when given the chance and the subscription man got more than the cost of the book out of it, in the satisfaction of knowing that a good turn had helped another to succeed.

National Feed-Water Heater and Oil Separator

One of the recognized advantages of the closed feed-water heater is that the feed water is kept free from the exhaust steam which may contain considerable oil. This type prevents the oil from getting into the boiler even if no separator is used. When installed, the condensed steam continually leaves the heater through the drip pipe, which should always be left wide open.



COMBINED FEED-WATER HEATER

In some installations this condensed steam can be used to advantage in ice making, for washing, or by returning it to the boiler together with drips from a heating system or other apparatus. But the oil must be gotten rid of, and it is usually easier to take it out of the exhaust steam than to filter it from the condensate.

To facilitate this operation, the National Pipe Bending Co., New Haven, Conn., has made a special closed heater with a separator forming part of it, as illustrated. The separator is placed at the bottom of the heater so that the exhaust steam will impinge upon the baffles, and by change of direction and in passing through the ports shown, will be freed from particles of oil without materially adding to the back pressure on the engine.

Nations to Be Represented at the Exposition—The following extract from a recent official bulletin on the Panama Pacific Exposition work should be of interest to prospective exhibitors and visitors: "The following foreign nations have accepted the invitation of the United States to participate in the exposition: Argentina, Bolivia, Brazil, Canada, Chile, China, Costa Rica, Cuba, Denmark, Dominican Republic, Ecuador, France, Guatemala, Haiti, the Netherlands, Honduras, Italy, Japan, Liberia, Mexico, Nicaragua, New Zealand, Panama, Persia, Peru, Portugal, Salvador, Spain, Sweden, Turkey, Uruguay, Venezuela. It is now assured that practically all the states of the Union will be represented.

Three-Wire Generator with Revolving Compensator

The adoption of a revolving compensator with one collector ring for obtaining the neutral connection with three-wire operation is embodied in a design recently brought out by the General Electric Co., superseding the familiar separate stationary compensator and two-collector-ring arrangement. The revolving compensator consists of a circular magnetic core upon which are mounted suitable exciting coils, the core with its coils being assembled on a cast bracket bolted directly to the back end of the armature spider, as shown in Fig. 1. The compensator fits under the overhanging end windings of the armature, projecting only a short distance beyond the main winding.

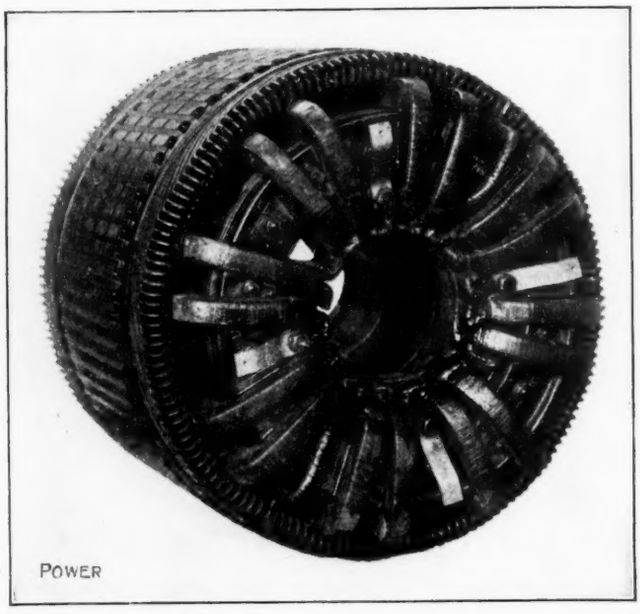


FIG. 1. ARMATURE WITH REVOLVING COMPENSATOR

The compensator windings are connected to the main armature winding at proper points, and the neutral connection is taken through the armature spider to a single collector ring mounted on the outer end of the commutator shell. This ring may be seen in Fig. 2. The neutral brushes bearing on this ring are supported by and insulated from the main brush-holder studs. The simplicity of this design, self-contained with the armature, eliminates floor space taken by the stationary compensator, requires fewer collector rings and brushes and reduces the number of cable leads to the switchboard. These generators are of the commutating-pole type.

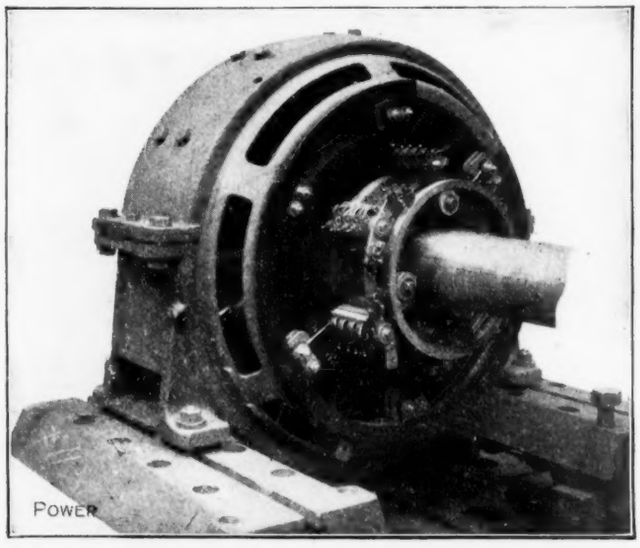
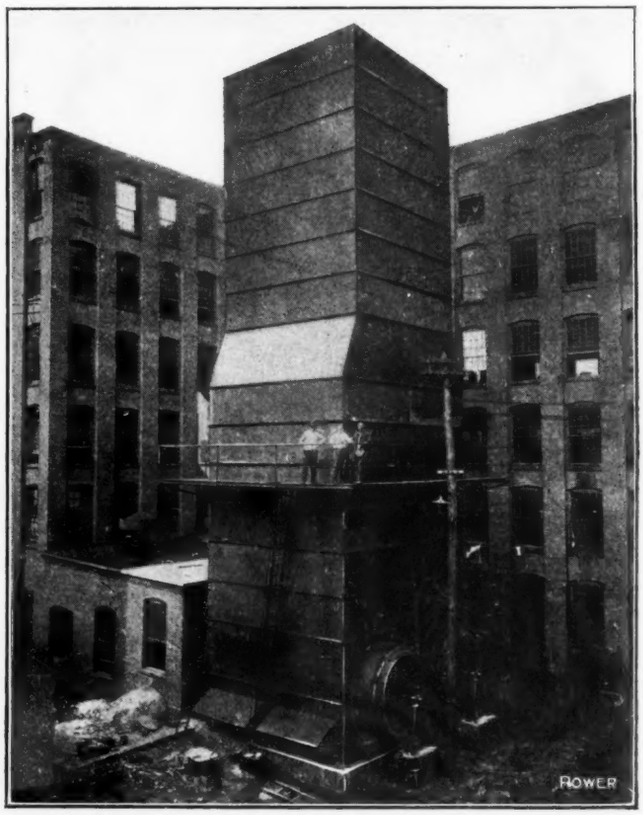


FIG. 2. 250-VOLT, THREE-WIRE GENERATOR, SHOWING COMPENSATOR RING

Large Wheeler-Barnard Cooling Tower

The illustration shows a large twin Wheeler-Barnard, forced-draft cooling tower, recently built by the Wheeler Condenser & Engineering Co., Carteret, N. J., for the American Hardware Co., at its New Britain, Conn., plant. The capacity is 132,000 gal. per hour, cooled from 100 to 80 deg. F.

The tower proper terminates just above the platform on which the men are standing, the steel plate work above this being a stack to convey vapors above the roof of the building, and also to provide natural draft for operation in cold weather. The tower is designed with special air inlets which are opened when the fans are not in use and the stack supplies the draft. They consist of counterweighted doors, which when opened, provide a large area for the inlet of air.



COOLING TOWER WITH FORCED AND NATURAL DRAFT

The unit consists of two towers arranged side by side, each 11 ft. 5 in. wide and 18 ft. 3 in. long, erected over a reservoir which also serves as a foundation for both towers. The chimney is 18 ft. 3 in. square and the height from the base of the tower to the top of the stack is 70 ft. Forced draft is supplied by four 108-in. fans.

Refrigeration Plant Troubles and Remedies

By William S. Luckenbach

SYNOPSIS—The article is replete with solid, practical hints and instructions. It tells what indicates weak ammonia; how to calculate the amount of fresh ammonia required; why ice gets dirty; cleanliness of ice as influenced by carelessness in pulling the ice; cold losses induced by irregular pulling of the ice; filling of cans and failure to keep brine tank properly covered.

Proper Arrangement of Cooling Coils

Coils in the brine tank of all machines of over three or four tons capacity should be in sections of from four to six coils per section, with a division in the center of the section. This is better than one continuous header, for the coils furthest from the expansion valve will receive more than their share unless there is a valve on each coil to govern the supply. To nicely regulate the flow of the gas requires considerable skill and judgment, and at best the result is not satisfactory because the quantity of gas required for a few coils is so small that it is difficult to set the valves properly.

On the other hand, if all the sections are connected to one main header and are regulated with one expansion valve, the distribution of the expanded gas will be fairly equal over the entire tank. Each section, however, should have a controlling valve, and each coil, at both top and bottom, should have a valve in case of accident so that any coil or section could be cut out without interfering with the plant. There is no set rule as to the proper amount of liquid to feed or allow to pass through the expansion valve for any number of coils.

We will assume that the liquid ammonia on the high-pressure side is, say, 99 per cent., pure and is at normal pressure regardless of the style of machine. Open the expansion valve slowly and note the frost on the pipes. If they frost nicely, open the valve a little more at intervals, until the frost gets moist, then close slightly as you have reached the maximum of expansion under that pressure and temperature. As the proper capacity depends largely on the purity of the liquid ammonia, it is of the greatest importance to test it occasionally. The method of testing the ammonia for purity has been described in a former article.*

If it usually is pure and the test shows moisture after evaporation, it may be due to the rectifier, or to allowing the rich liquor in the generator to get too high and cause a partial boil-over in the generator. Should the frost beyond the expansion valve, become moist or drop off, it is an indication that the liquor level in the generator was, or is, too high. If still too high, stop the ammonia pump until the proper level is restored. When the freezing tank is above the absorber (as it should be) and the pressure in the absorber is lowered, the accumulated ammonia in the brine tank coils will flow to the absorber by gravity. If, however, the absorber is on a level with the tank, then create a vacuum in the absorber for a few minutes by closing the weak-liquor valve and start the ammonia pump. After the liquor has been drawn into the absorber, which will be indicated by the rise of the liquor in the gage-glass, open the weak-liquor valve again and run the pump to suit the proper level in the generator. As the temperature of the brine will rise during this time, the machine will require special attention until normal conditions have been restored.

*"Power," Mar. 24, p. 411.

Loss of Liquor

After a machine has been in operation for some time, the liquor in both the generator and the absorber may fall, perhaps without any apparent cause. In a new plant it may be due to an insufficient original charge, providing the rich liquor remains the same in density; but, if after restoring the proper level it falls again and the strength is also less, there is something wrong. First, the cooling water of all the coils and the brine must be tested with litmus paper or Nessler's solution† to determine if there is any leakage of ammonia. If there is no leakage, the loss may be due to some of the liquor being pocketed in a low place in the piping system or in the expansion coils in the brine tank, when that tank is so located that a gravity flow to the absorber cannot be established. In that case, the liquor must be drawn into the absorber by a vacuum. If this should not normally restore the level, air may have been trapped in the top condensing and cooling coils and found its way slowly into the absorber, where it has been burnt off at the purge cock and some of the air space filled with liquor.

Making Up Ammonia Losses

In absorption machines, aqua ammonia should always be kept at the standard density of 26 deg. Baumé; 27 or 28 deg. is preferable, providing the ammonia pump is in condition to handle it. This is especially advantageous when the generator is using exhaust steam because it requires less heat to liberate the necessary percentage of gas, and the weaker the rich liquor, the higher the temperature of steam needed to liberate the same percentage of gas. We will now assume that the rich liquor has weakened to 24 deg. Baumé and that we wish to increase its density to the standard, 26 deg., by adding liquid ammonia. The amount to be added may be found in the percentage table of strength of ammonia liquors. Aqua ammonia at 26 deg. contains about 28 per cent. of pure ammonia and at 24 deg., 24 per cent.; the loss is 4 per cent. of pure ammonia.

Suppose that the original charge was 10,000 lb. at 26 deg., 28 per cent., or 2800 lb. is pure ammonia. Then 4 per cent. of this quantity, 112 lb., will again bring the whole charge up to 26 deg. The simplest method of introducing it is to connect directly to the brine and take up heat. Then it is only necessary to see that it is not admitted to the coils faster than the weak liquor flowing into the absorber can absorb it. Again, suppose we wish to use aqua ammonia

†See "Power," Mar. 31, p. 450.

to increase the strength, but find that this cannot be done until some of the weaker liquor in the system has been withdrawn. We also want to know about how many drums to order without guessing, so as not to have a drum or two about the place for which we have no use. Take the same example of 10,000 pounds originally with 4 per cent. loss of pure ammonia. In distillation, it is difficult to get below 12 deg. Baumé, or 2 per cent. additional loss on the whole amount, but as only a small part of the 10,000 lb. is distilled, the actual loss would be approximately 4½ per cent. of the 2800 lb., or 126 lb., and as aqua at 26 deg. contains about 28 per cent. of ammonia, the balance, 72 per cent., would be water. Thus we need $126 \times 0.28 = 35.3$ lb. of new ammonia.

The quickest way to distill the liquor to 12 deg. is: Stop the pump and close the poor-liquor valve, leaving the gas and the steam valves open, as well as the expansion valve. This will reduce the pressure gradually in the condensing coils. When the density has been reduced to about 12 deg., close the gas and the steam valves, draw the required amount at the bottom of the generator and pump strong liquor to replace the weak. Now open the steam valve, but do not open the gas or poor-liquor valves until the generator pressure is about equal to the poor-liquor pressure due to its head or height above the liquid in generator, otherwise the generator might be flooded. Next open the valves slowly; the machine, however, will need careful attention until the pressure and the liquid levels are normal.

Purity of Ice

Artificial ice is made either from distilled or ordinary drinking water, usually termed raw water, but when steam is the prime mover, distilled water should be used because of its purity. Where raw water is employed, the first requisite is pure water, or such as can be made so by chemical treatment. Furthermore, air agitation is essential, either by the can or the plate system, to avoid white or opaque ice. The can should have a capacity of not less than 300 lb., thus avoiding a multiplicity of connection from the main air pipe. This pipe should be close to the return gas pipe in order to reduce the air temperature at least as low as that of the water in the cans or tank. Distilled-water can ice should not be frozen at a lower temperature than, say, —10 or —12 deg. F., because the ice forms more rapidly when directly in contact with the can and may give an opaque appearance on the outside of the block.

Opaque ice from distilled water is frequently due to carelessly handling the can filler when the can is full. Withdrawing the filler should be done with as little agitation as possible. The causes tending to make excessive core and dirty bottoms are numerous, such as impurities in the water carried over with the steam, especially if the water in the boiler gets too high; insufficient reboiling of the distilled water, fluctuating level in the distilled water tank or forecooler, thus alternately exposing and covering the coils or pipes, and invariably washing off some dirt. A dirty filter is another cause. One common cause that is frequently overlooked or underestimated is that due to dirt accumulation on the top of the freezing tank. The cleats on which the bath lids rest must be clean; dirt must not drop into the cans. The top of the lids should be free from dirt also, because dragging the bottom of one lid over the top of another is bound to carry dirt with it and deposit it in the can. The engineer will usually investigate every place but the dirty lids. Put a good mat at every entrance to the freezing tank, and over each entrance place the sign, in large letters, *"Wipe Your Feet."*

Both the raw and the distilled water should be tested occasionally for purity. This can easily be determined by using nitrate of silver or chloride of barium. To find which is preferable, especially in distilled water, draw two glasses of water from the feed to the steam boiler, put two drops of nitrate in one glass and two drops of chloride in the other. The chemical showing the greatest precipitation should be used, and if the water in the tank or the cans prove to be pure, there is no need to go further. If, however, the distilled water is impure, a second test should be made from the pipe leading from the distilled water tank to the filter. If this is pure, it is plain that the fault is in the filter. On the other hand, if the water shows a precipitate, the fault is either in the distilled-water tank, the generator or the steam boiler, and the test should be continued.

In case one can taste or smell ammonia in the water, about the same method would apply. This trouble may be in any part having return gas pipes passing through it, or it may be a leaking steam pipe or coil in the generator. After having determined the origin of the trouble, cut one coil or tube out at a time until the defective one is reached, then cut that out of service entirely. Locating this may take some time, and it may be advisable to use raw water instead of ammonia-impregnated, distilled water. Should the defect be in one of the generator tubes or coils, it may be temporarily necessary to either use a higher strength aqua ammonia or a higher steam temperature to liberate the percentage of gas for normal capacity because of the loss of one tube or coil.

Pulling Ice and Filling

It is essential that the stated number of cans be drawn every hour. If more are pulled at any time, the economy of the plant is disturbed, especially where distilled water is used, as the water will be warmer if the extra cans are filled. If they are not filled, the brine will be lower on the outside of the other cans in the bath and, of course, decrease the output to that extent. The surface of the brine, where the extra cans have been withdrawn and the lids left off, will also be exposed to the temperature of the atmosphere, which is usually about 65 or 70 deg. warmer than the brine. This practice is inexcusable.

The exposure of the brine to the surrounding summer heat should never be longer than necessary for the withdrawal of a few cans or a plate block at any one time, and all hot air from the engine or the boiler room likely to increase the temperature on top of the bath must be prevented from getting in the freezing room.

If there is likely to be a shortage of distilled water, start filling as soon as the water runs at the overflow of the tank, regardless of whether it is just on the hour. Have a few extra cans, so that the cans from which the ice has been dumped can be turned down and well drained, thus preventing bad butts or second-quality ice.

Many of these suggestions may seem of little consequence, but in the aggregate, the loss can be readily seen and computed by any progressive engineer and be appreciated by the owner. Proper attention to all these matters requires but little of the engineer's time after a proper system of daily inspection has been established.

Editorials

Helping the Helper

By the very meaning of the words "assistant" and "helper" the engineer regards his subordinates as for the purpose of assisting and helping him. How often does he think that there is any return obligation on his part? Many engineers are humanly interested in those working under them, and thanks be to such men! In times gone they have done much to raise up worthy successors to fill their places and there is still a goodly number doing it, some if for no other reason than that they ought to do it because someone once did it for them. A few—we hope they are exceedingly scarce—are so small-minded that they fancy it is prejudicial to their own good to teach helpers too much, lest they displace their teachers too soon.

No, we like to feel that, if there is a growing disposition to neglect the instruction and counsel of his assistants, the engineer is doing it from force of circumstances—not deliberately. In small plants, and all plants were small in the old days compared to the present average ones, there was time to give some thought to the welfare of the young chaps who were just learning the gentle art of plant operation. Today, the chief usually is a very busy man; his mind is occupied with many large propositions; he is keener of his responsibility to a critical management, and he has little leisure to consider the needs of those under him. They must be capable assistants or his natural tendency is to look for others rather than train them to the proficiency he requires.

This is a serious condition of affairs if we did but realize it. Somewhere, these beginners must get their education in power-plant practice. Schools have come into existence to do a great deal of this work and are filling an important economic need. Still, not all young men have the time or the funds to go to school. They must get to work for their own support, and often the support of others dependent upon them. You older men, have you ever thought what a severe handicap these young men have placed upon them? Is it not your habit to comment, if at all, on how much greater are the advantages enjoyed by the youth of today compared with what you had? Where there are many who do enjoy advantages, there are some who do not. They can see only the much greater amount of information they must have to handle the more complicated equipment and to handle it in keeping with the more exacting standards now imposed. Worst of all, they are expected to have this knowledge when they start and are in fear of discharge the moment their shortcomings are discovered.

Here is a thought: Just suppose you give these men who are on your staff somewhat the same consideration you do the plant equipment under your charge. Treat them at least as well. You find a certain piece of apparatus not up to its proper performance. What do you do, scrap it? Hardly; your employer would probably object if you wanted to. So you first examine it to see if it cannot be improved. Possibly it is only a little out of adjustment, or it is worn, or even broken in some minor part, when you examine into it. A little time spent in renewing defective parts or overhauling, with little or no expense, and it goes on doing as good or better work than before.

Now, how about the oiler or fireman who is not doing the kind of work you expect? If he has not got it in him to be a better workman, you do him a service in discharging him, with the advice to get into some line for which he is better fitted. But be sure you give him a chance if he deserves it. Show him why this or that way he has of doing something is not right. Then teach him to do the right way himself. Incidentally, you will get a loyalty in that man which money cannot buy.

Another thing, do not be unreasonably harsh with your men over their faults. Cursing them is just as foolish as banging a balky pump with a hammer, and does about as much good.

You can carry this analogy between your men and your machinery as far as you like. Really they are both machinery in a way, and how much more important it is to be patient with human machinery, for that can manifest appreciation in return. If you are not appealed to by higher motives, there are plenty of selfish reasons for your helping the helper.

Should Heating Boilers Be Insured?

However much our respect for the destructive possibilities potential in a boiler carrying high-pressure steam, we are inclined to underestimate such ability in a low-pressure heating boiler. The latter looks innocent enough. It would seem ridiculous to think of requiring licenses to operate heating boilers and, it is true that, in proportion to their number, relatively few of them so far forget their good manners as to do much serious damage.

Nevertheless, when we read of an occasional heating-boiler outbreak, such as that described on page 622, it may well cause us to pause and consider. Fortunately, in this instance, no lives were lost. The building was a church and empty at the time, but, had the explosion occurred during a service, the loss of life might have been appalling. This consideration of the much greater number of people likely to be within the range of harm from a heating boiler as compared with a power boiler emphasizes the importance of giving them an equivalent amount of attention to prevent disastrous mishaps.

This Des Moines accident was not the only recent one of the kind. Within a few months, at least three serious heating-boiler explosions have occurred. The further quotation in the present article from the British Board of Trade report on a similar explosion shows how general is the experience and how especially needful it is that interest to the point of action be aroused for some-

thing to be done to reduce the menace accompanying an unintelligent handling of heating plants.

We hold no brief for the insurance fraternity, but the good work it has done in the direction of diminishing power-boiler accidents naturally suggests its probable usefulness in the broader field. Again, to cite the explosion mentioned in this issue, there was a ten- to twelve-thousand-dollar property loss uncovered by insurance. Few power-boiler explosions involve a larger amount.

Laws of the right kind would doubtless be a help, but legislation is a slower remedy than insurance on account of the delays in getting it established. However, no one agency should be relied on entirely. Compulsory inspections would be the best protection. Next to these come those that are furnished by the insurance companies wherever they issue policies. Much can, therefore, be accomplished when the public is convinced of the occasion to insure heating boilers and finally, and most immediate in their effects, once their importance is recognized, are the precautions which individual owners could and should take for their own good. Several of these are noted in the British Board of Trade report and deserve repetition here:

Provide safety valves.

Hire competent attendants.

Post in a conspicuous place printed instructions for the care and use of the apparatus.

See that these instructions are understood and followed.

Have periodical inspections by qualified experts.

Install reliable equipment.

Practically all of these precautions will be enforced when insurance is taken out on the plant, and the owner will have the satisfaction of knowing that if any loss does follow he will be recompensed financially.

Inside Inspection

It is second nature for every engineer, as soon as he comes on duty, to inspect the machinery under his care. He feels the bearings; sees that all the oil cups are full and that the oil is flowing freely; he notes that the needles on the switchboard instruments and the steam-pressure gage are pointing to their proper figures. Automatically and as a matter of habit, he repeats these observations at fairly regular intervals throughout his watch.

There are some engineers who consider that this daily round of routine inspection is the extent of their job. Fortunately for all concerned, their number is daily diminishing. They regard such work as keying up of loose brasses or adjusting governor springs as necessary but incidental. As for removing cylinder heads, opening valve chests or lifting out main bearings at opportune moments, to know the true state of an engine, the number of reasons for not doing these things which an indifferent engineer can give is astonishing. The common ones are: "Too busy"; "What's the use?"; "She's always run all right"; "This engine has never cost a cent for repairs so far."

This "let-well-enough-alone" sentiment is now so common in almost every line of business as to scarcely excite comment, even from those most interested. In the engine room, however, it must be banished. The failure to periodically look into and overhaul every piece of mechanism and piping in a plant sooner or later brings disaster. Breakdowns, interruptions in service, increased operating costs—these are the dread of all conscientious engineers, yet all of them can be practically eliminated by a thorough search for concealed defects.

No machinery can be expected to keep up to its original performance after its working parts have begun to wear, but the wear on essential parts, with the consequent loss of efficiency, can always be kept within reasonable limits and generally made a negligible quantity by systematic inspection to discover and remove any source of wear before it can do harm. As an instance, consider the worn and leaky piston ring. It may be responsible for the loss of only one-twentieth of a pound of steam per stroke, yet in the average engine doing its hundred revolutions per minute, ten hours a day, this represents a daily waste of six thousand pounds of steam.

After a wide-awake, enterprising engineer has entered a plant to take up the burden laid down by an indifferent engineer, it is the expected that always happens. The operating costs gradually decrease as one by one the various units are inspected, their particular defects discovered and the proper remedies applied.

Tuning Up the Refrigerating Plant

Now, as the time approaches to put the refrigerating plants into commission which have been idle during the winter, the article on "Ammonia Fittings," in another part of this issue, is timely. The reasons for many of the piping troubles due to leaks will be apparent when the various types of joints are understood. To those of long experience with refrigerating equipment, there may be little in the article referred to that is unfamiliar, but others more accustomed to the fittings common to steam and water lines will find many helpful points in this article. Modifications in present systems may be suggested by a better appreciation of the peculiarities of the usual forms of ammonia fittings or of the variety of forms that is available, some offering possibly better substitutes for those now in use.

We also commend to the attention of all concerned the "Accident to Ammonia Compressor" and especially "Refrigeration-Plant Troubles and Remedies," the other two refrigeration articles in this number, and for the benefit of any who may have missed them, the following recent ones which may prove of assistance while getting in shape for the summer service:

"Practical Refrigeration-Plant Suggestions," Mar. 24, 1914.

"Testing for Ammonia in Brine," Mar. 31, 1914.

"Starting and Stopping an Absorption Refrigeration Plant," Apr. 21, 1914.

A German statistician states that the rapidly increased used of electricity over gas in several German cities in the last ten years is, in some instances, two to threefold. It is probable that, as in our large cities, the energy and tenacity of the lighting and power interests are responsible for the decreased use of gas. While gas is at present holding its own in the smaller communities, it is contended that it is mainly because the small field is held in altogether too much contempt by the electric-lighting interests.

Correspondence

Operating Condenser without Hotwell Pump

The article on this subject, on page 75 of the Jan. 13 issue, was interesting to me, as I have from time to time had to run a condenser with the hydraulic air pump doing all the work.

The turbine is usually running at full load, about 1150 kv.-a. We found that with the extractor pump shut down, we could still run with 94 per cent. vacuum (instead of the usual 96 per cent.), corresponding to an output of 1050 kv.-a., for about 4¼ hr., when the vacuum would fall rather quickly. As the vapor and air pipe to the air pump is taken from about halfway up the condenser side, the latter was filled so far with condensed steam.

When the vacuum, and consequently the load, dropped, the only way to restore it was to shut down the steam side, drain the condenser and start over again, the whole operation taking about half an hour. As the machine was on a large alternating system, the loss of load was not serious. Considering the largely reduced tube surface, 94 per cent. seems a remarkably high vacuum to hold. It is difficult to account for the sudden periodic fall. Obviously, the air pump must have been dealing with condensate as well as air and vapor for a long time before it failed. The theory that the condenser is much too big for its work will not hold, each set being complete and modern.

R. Dilworth Harrison.

Middlesbrough, Eng.

Where Should the Oil Separator Be Located?

Answering G. S. Sprague as to the above query, I have had similar trouble, and will explain how I overcame it.

My oil separator was located practically in the same place as Mr. Sprague's, but where he shows a drain to the sewer that he closes when running, I installed a low-pressure trap with a swing check valve between it and the exhaust pipe. The line is open all the time and water and oil cannot collect in the bottom of the horizontal run at light loads and then be thrown over too fast for the separator to take care of when the load increases.

I also tapped the drain connected to the separator a size larger and connected the pipe to a tee in the trap line between the trap and the check. Since making these changes, I have had no trouble with oil in my returns; before, I had plenty.

There is less waste by using a trap than to pipe direct to the sewer or to put in a valve and just crack it enough to let the water out, as I have seen done in many plants. When this is done the opening is not enough, when the back pressure is light, to let the water and oil out, or if it is opened too much a great amount of steam is wasted. The trap also acts to a certain extent as a receiver, and the separator does not become flooded as it otherwise would when first starting or upon starting another engine or pump connected to the same exhaust line.

A. O. White.

Genoa, Neb.

[Since publishing two letters in reply, there have been several others received. All agree in general terms that the location is not responsible for the failure. This one describes a similar difficulty which has been overcome and is therefore given preference.—Editor.]

Heated Air for Steam-Boiler Furnaces

The letter on this subject, by Mr. Odell, published in the Dec. 30 issue, has recently come to my attention. Although the letter is old, it raises questions, the discussion of which should prove interesting. Mr. Odell asked why heated air is not more generally used, when such economical results are possible as proved by the tests financed by an association of manufacturers. The present limitations to the use of heated air are due to the characteristics of the fuel—that is, the plan has failed because with average coals it has caused excessive formation of clinker.

Providing the ash contains substances which will fuse, clinkers will form when the ash is subjected to a temperature higher than its fusing point. Fortunately, the surface of the fire is usually the hottest part, and from there to the grate the temperature gradually decreases, slowly at first and then more quickly as a region is reached where much of the combustible matter has been burned out of the coal and the cooling action of the air coming up through the grates is not offset by the intensity of combustion. Thus as more and more of the ash particles come in contact they are working down into a cooler part of the fire, and unless they melt at a comparatively low temperature they will not melt and run over the grate, even though the melting point of the ash is less than the temperature of the upper part of the fire.

In numerous boiler tests it has been found that when the melting point of ash falls much below 2400 deg. F., clinkers are formed, while coals having ash melting at 2600 or 2700 deg. F. give little trouble under the same boiler rating and draft conditions.

If the air supply to the fire were heated 250 deg.—that is, if it went into the ashpit at a temperature of about 300 deg. F.—the temperature of the fire would be about 250 deg. higher all the way through and the coal having ash which melts at 2400 deg. F. would be in the same position as the one in which the ash fuses between 2100 + 220 deg. F. with cold air supply. To get a coal which would give even tolerable results, it would be necessary to obtain one where the ash would not melt below 2650 deg. F. There are only a few regions which can

supply a coal of this character and these must be carefully prepared at the mine and are expensive.

On the other hand, the system would effect large economies, for the efficiency of the boiler would be increased 3½ and 4 per cent. for each hundred degrees of heating of the air supply; this would mean a coal saving of 5 to 5½ per cent., provided this heat were taken from some source of waste heat. In this way the air heater would act like an economizer and reduce the temperature of the gases, so that a fan or a very tall stack would be required to maintain the draft. Where conditions warrant the complication and expense, an economizer will give the same operating efficiency with less incidental troubles and get the benefit of this heat which otherwise would have to be used in the air heater. In other words, if you have an economizer, there isn't heat enough left to operate an air heater, and in a choice between the two the advantages are all with the economizer.

On shipboard, where the weight of an economizer would be prohibitive, air heaters have been used quite extensively, as in the Howden, and the Ellis and Eaves systems, the chief difference being that Howden's system uses a forced-draft fan and closed ashpit, sending the air to be heated around the tubes of the air heater, while the Ellis and Eaves system uses an induced-draft fan and draws the air to be heated through the tubes. In neither does the air supply attain a very high temperature.

With oil-burning boilers, where there is no clinkering to be considered, this is an ideal arrangement, as it produces a short, hot flame and aids in obtaining smokeless combustion with a minimum quantity of air. Heated air injected into a locomotive firebox, as in the Parsons system, has been used with good effect both in improving smokeless operation and economy, provided the air was hot enough and the right quantity was supplied. I hope that this will explain to Mr. Odell some of the difficulties incidental to air heating for boilers.

H. D. Fisher.

Newton Highlands, Mass.

Settling Chamber for Filter Coke

Mr. Fenwick, in a letter under this title in the Apr. 7 issue, shows how the small pieces of coke used in some of the open-type feed-water heaters may be prevented from going into the feed pump.

At one time I had considerable trouble with an open heater. The floor of the coke chamber is made of iron plates having a large number of small holes through which the water passes, but it retains the coke, and the pump suction is taken from below this plate. The greatest trouble was just after putting in new coke. The method we used to prevent it was to spread a layer of burlap, such as comes around bales of waste, over the iron plates. This will allow the water to pass through, but will prevent anything but the finest of the coke from passing. This burlap will also catch much of the scale-forming matter which passes through the coke. Usually, a new piece is used each time the filter is cleaned.

The idea presented by Mr. Fenwick is not entirely satisfactory in that the coke is light and will not readily settle into the trap; it would likely be carried by with the water to the pump. If a strainer of small mesh were inserted in the joint just above the tee, the coke would be stopped, but a strainer located at this point would soon clog up, although it probably could be flushed off by opening the valve at the bottom of the trap leg.

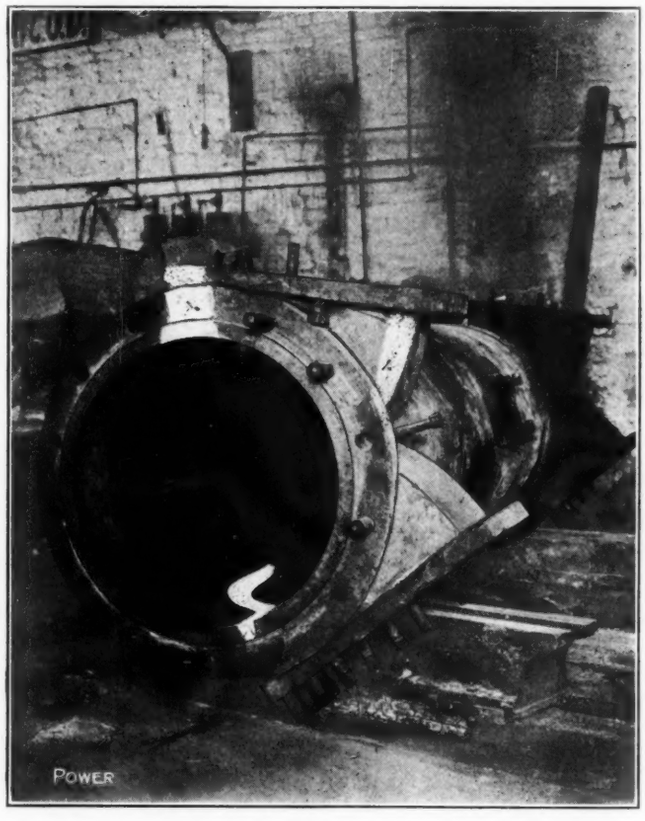
In addition to the burlap on the bottom of the coke chamber, we also found it advisable to place a layer of burlap over the coke with a few bricks piled on top to hold the coke down. The reason was that it would float and work into such position that it interfered with the ball float controlling the feed-water inlet. We were also advised that hay was much better to use in the heater in place of coke as the hay would hold back more of the scale-forming matter which was precipitated in the heater, and some of which would pass over with the water to the boilers. We only used this once. It would not last long, and gave too much trouble from breaking up and passing through the heater to the pump.

J. C. Hawkins.

Hyattsville, Md.

Large Engine Cylinder Welded

The illustration shows a steamboat-engine cylinder 24 in. by 8 ft. that was damaged by a "dose" of water. The cylinder was cracked in two places for 18 in. in the direction of its length, and big lugs were broken out of the



Where the Engine Cylinder Was Welded

steam chest. A new cylinder was telegraphed for. The reply was that the builders who made this cylinder were out of business, and had been for seven years. For making a new cylinder a local iron works would charge $720, and it would be at least two weeks before the boat could be put back into service.

As a last resort, a welding concern was given the job

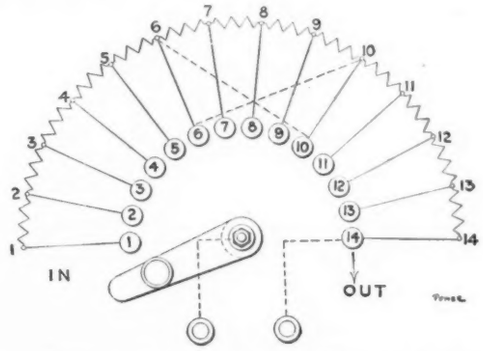
of patching and welding the cylinder. The job was done in 36 hours for $66, after which the boat steamed up the Mississippi River, and has been in constant service for the past three months.

J. W. Dickson.

Memphis, Tenn.

Field Rheostat Trouble

Engineers accustomed to keeping a constant check on the existing condition of their equipment so as to be able to promptly trace the cause of irregularities that may occur, mark the positions of their generator-field



Contact Points Connected to Wrong Resistances

rheostats both for cold field and for hot field. The advantage of this is illustrated by the following:

An old rheostat that had been in use for years was taken apart to fix an open-circuited connection. As several of the dial leads proved to be in bad condition, they were renewed also and reconnected. On reinstalling the box and placing the handle bar upon a marked dial plate corresponding to no-load normal voltage, the machine promptly built up to normal voltage and everything was assumed to be all right. After the machine had heated under load, however, it was found that upon placing the rheostat in the position marked for this condition, the machine undercompounded considerably.

The engineer naturally suspected a fault in the rheostat because that was the only thing that had been disturbed. On removing the rheostat panel and checking the connections, he found leads 6 and 10 interchanged, as indicated by the dotted lines in the sketch. The interchange happened to involve the No. 10 plate that held the hot field mark, with the result that advancement from plate 9 to plate 10 cut in four resistance sections instead of cutting out one section. With two machines in parallel, such a condition might have caused trouble, but the engineer discovered it in time.

J. A. Horton.

Schenectady, N. Y.

Why This Ice Plant's Capacity Was Low

Recently a new ice plant which had been in operation only a few weeks began to drop off in capacity, and as matters got worse, an engineer was called in to locate the trouble. He found that the freezing tank coils were heavily coated with salt. It developed that when the brine was made, before the plant was put in operation, the erecting engineer had used so much salt that after the water had taken up all it could hold in solution, the balance was deposited on the coils and crystallized there, forming an insulation between the ammonia in the pipes and the brine.

It appeared that after the brine was brought to its proper density, there were several bags of salt left over; the erecting man dumped them into the freezing tank rather than bother with shipping the salt back to the factory.

The brine was drawn out of the tank and the coils and tank cleaned, after which the brine was put back and enough fresh water added to bring it down to its proper density.

Each coil was fitted with drain connections at the bottom which passed through stuffing-boxes at the end of the tank. The drain valves on each coil were opened and 32 gal. of ice-machine oil drawn off. This showed that the oil trap on the discharge line between the compressors and the condensers were being neglected and that too much ammonia oil was used.

After the plant was put in operation the second time there was no further trouble, and the plant developed its capacity.

Jacksonville, Fla.

C. T. Baker.

Ignition-Trouble Remedy

In a producer-gas power plant, which came within the writer's observation, considerable trouble was experienced with the engines missing. An investigation showed the cause to be in the make-and-break ignition system, the heat from the spark periodically welding the nickel-composition electrodes together; they would stick for a time, causing the engine to miss, then break loose again. These nickel composition electrodes were replaced with cast-iron ones and there was no further trouble from this source. The arcing surfaces of the cast-iron electrodes seemed to wear smoothly, not having the tendency to pit and corrode, as in the case of the other electrodes.

C. J. Barton.

Chicago, Ill.

Oil in Boilers

This is an old subject, but it frequently comes up in boiler-room practice. No set of rules can cover all cases and long experience is most essential in correctly judging how to remedy troubles due to the presence of oil.

After years of experience with this problem in our plant, we seem to have arrived at a fairly satisfactory solution of it. The condition was bad as the boilers were so caked with oil and grease impurities that a dozen tubes had to be replaced before the boilers could be put in service. All possible means were adopted to prevent the oil from getting in, but still some got into the boilers. A compound cylinder oil had been used which contained a high percentage of animal matter. The oil seemed to emulsify in the water and cause the foreign matter to adhere to it, the entire mass settling to and depositing on the shell, where it would bake, forming scale which prevented the water from making good contact with the heated plates. The scale was not hard and could be easily shoveled out when the boilers were opened.

It was decided to make a change in the oil and use a pure mineral oil which would not cause foreign particles to adhere to it and would, therefore, stay on top of the water. Surface blowoff pipes were provided; they were used daily and reduced the accumulation materially. In opening the boilers it was found that while there was practically no deposit in the bottom, there was a considerable coating of oil in the zone of the water level. While perhaps not dangerous, this condition was still unsatisfactory as the accumulation was difficult to get off, as well as forming an insulation from the heat of the gases.

The boilers are of the return-tubular type, in which the gases make a pass over the top of the shell. As a last resort, soda ash was fed weekly into the boilers, with a daily use of the surface cock and bottom blowoffs. The boilers are now 11 years old and it so happens that the same inspector has been inspecting them for the major part of that time. He reports that they are now in better condition than ever.

EDWARD T. BINNS.

Philadelphia, Penn.

Experience with Gas Burners

In changing from coal to gas fuel the Oklahoma Gas & Electric Co. encountered several obstacles which taxed the ingenuity of the engineers.

The boilers were of the ordinary water-tube type and were unchanged except for the firebox being remodeled for gas, and a type of gas burner was used, as shown in Fig. 1. It consisted of a pipe with a bell-shaped mouth, the end having adjustable shutters for air regulation. The gas was admitted to the burner through a ring situated around the burner tube with circumferential openings into it. By means of the air shutters and the gas valve any desired proportions of air and gas could be obtained. The burners were fixed in the furnace wall, as in Fig. 2.

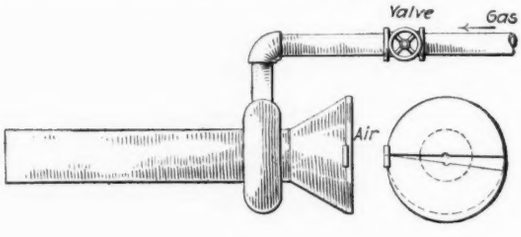


FIG. 1

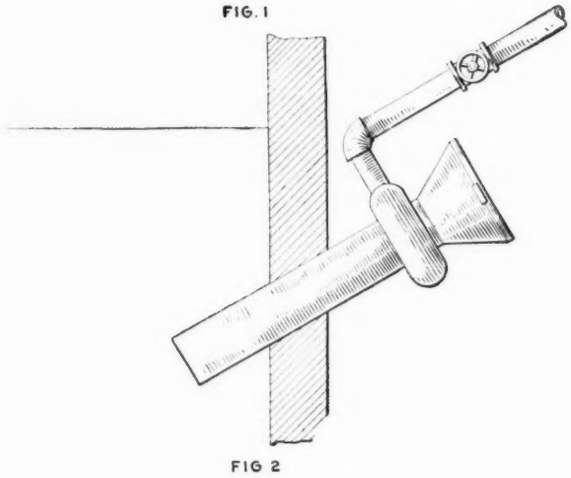


FIG 2

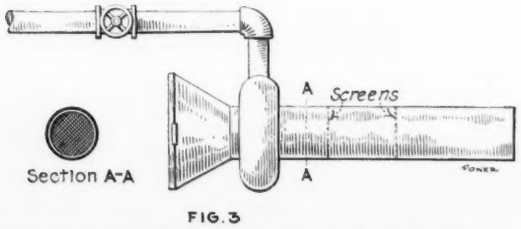


FIG. 3

GAS BURNER BEFORE AND AFTER ALTERATIONS

After installing the burners and putting the boilers in operation, they worked satisfactorily for a time and then, apparently without cause, there occurred cyclic explosions inside the firebox, causing severe vibrations of the boiler and rendering operation unsafe. Careful adjustments of the feed and remodeling the baffle walls and inside arrangements of the firebox did not remedy matters.

Various reasons were advanced for the cause of the explosions, the most plausible being that the air and gas were not mixed intimately in the burner tube so as to burn near the end of the burner, but were drawn back into the firebox before mixing and then ignited in such a large volume as to cause the vibration, this effect causing a partial vacuum at the burner end, thus drawing in another charge of fuel which in turn exploded.

In line with this reasoning, two wire screens were fastened in the tube near the furnace end, the first being coarser than the second; see Fig. 3. The screens seemed to effect a more uniform mixture of the air and the gas, and the explosions ceased. But that which was not anticipated, occurred as a secondary result—there was a diminution of 20 per cent. in the cubic feet of gas used per kilowatt-hour.

L. W. W. MORROW.

Norman, Okla.

Carborundum vs. Emery Cloth

In the Jan. 6 issue under "Inquiries of General Interest" and in the "Correspondence" of the Feb. 24 issue, reference is made to the danger of using emery cloth around a dynamo. Emery, most assuredly, is not fit to use, but I have found that carborundum cloth may be used without the attendant danger of loosened particles lodging between the bars and causing short-circuits, as emery will do. I have used it on commutators and brushes and have never had any but the best results.

After using the carborundum, however, it is best to blow off the commutator and brushes with compressed air or a bellows to prevent any particles from getting into the journals and cutting.

W. W. PETTIBONE.

Ludlow, Ky.

Value of Laboratory Coal Testing

Some time ago the plant shut down all night for lack of steam. The superintendent blamed the shutdown to poor coal. The coal was sampled and tested by the laboratory, and as the results were comparable with coal that had given satisfactory results, it was pronounced all right.

The tests were made on 50 lb. of finely ground and quartered coal taken from each car. The proximate

analysis included moisture, volatile combustible material, fixed carbon and ash. The moisture and ash are quantitative determinations, but the other two are empirical.

The superintendent, a man of 25 years' experience in power-plant work, maintained that the laboratory tests were worthless, they told nothing. The chief chemist, an experienced man, saw that the tests were carried out in the most approved manner.

The trouble in this case was in burning the coal. It was impossible to hold the load. How could the chemist tell how the coal was going to burn from the above tests?

These tests do not satisfy power-plant operators because they do not tell enough. Much ill feeling often arises between the power plant and the laboratory because too much is expected of these tests. They are inadequate, which shows the need of more practical methods of testing.

It would seem highly desirable to have an apparatus which could be placed in the power house to burn a sample from each carload under conditions closely resembling the actual situation under the boiler which would record the British thermal units per pound. The ash could be weighed, which would give the percentage. The burning of a 40- or 50-lb. sample of coal from each carload would give opportunity of watching the combustion, noting the coking of the coal and the physical properties of the ash.

I would like to hear what other power-plant operators and chemists think of the value of the laboratory tests of coal.

Chicago, Ill. C. J. Barton.

Bushing a Piston-Rod Gland

Referring to the article on page 440 of the Mar. 31 issue, "Bushing a Piston-Rod Gland," I have had a like experience.

On a Corliss engine, which has been in use for about 18 years, the rod was so badly worn that it was almost impossible to hold the packing in place. I had the gland bored out similar to the illustration just mentioned, but instead of using an iron or brass bushing, I obtained a good grade of babbitt to bush it. I could get a very close fit without fear of scoring the rod.

Previous to bushing it was necessary to put in new packing about every week. I sometimes had to keep the packing so tight that the rod would get hot, and at one time one of the gland bolts broke. The present packing has been running about six weeks and shows no signs of blowing; I keep the nuts just tight enough not to come off.

Knoxville, Iowa. Roy L. Peterson.

Cause of Corrosion of Pump Rod

I noticed, in the Mar. 17 issue, R. G. Lovell's inquiry concerning the corrosion of tin buckets. Considerable trouble was caused by the corrosion of the lower end of a pump rod of a deep-well pump. It corroded so badly that it broke and was replaced several times, as was also the lower end of the suction pipe, which extended to within 11½ ft. of the bottom of the well. The cause was never found, but it is thought to be due to the presence of sulphuric acid in the water. When the pump is at rest, the acid, being heavier than water, settles to the lowest point and forms a more concentrated solution which attacks the metal.

We presume that our analysis is correct, as only the lower end of the rod is corroded for a distance of about 18 in. above the plunger; the rest is as good as new.

We also had trouble with rusting and corroding tinware when water was allowed to stand for some time.

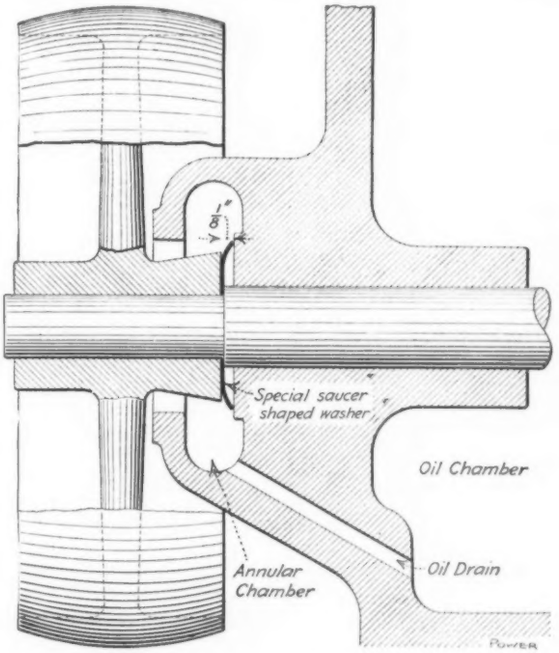
While I will not say that sulphuric acid is the cause of corrosion in Mr. Lovell's case, I think, on analysis, he will find that some such agent is responsible for it. Certainly graphite cannot do it unless there is some other compound mixed with it.

Pure graphite will never cause corrosion, and graphite paint is one of the best known protectives against corrosion. If Mr. Lovell will mix some of the graphite with boiled linseed oil to a paint consistency and then paint the buckets with it, I think he will soon find that the corrosion will cease.

Milwaukee, Wis. Frank Gartman.

Keeping Oil from Belts

On taking charge of a hydro-electric power station, I found the governor belts on each unit reeking with oil; this made it hard to maintain a constant frequency on the generators. The oil from the chamber leaked through the bearing to the pulley and belt. I cut a concentric



Disk in Place

washer of tin as large as could be put into the opening, and with a peen hammer I made it saucer shape and neatly fitted it on the shaft, which had a shoulder as shown. I first put on the tin washer, then with the pulley I forced it into its place, and drove in the cottter pin. The illustration shows the disk in place. New belts were put on and after eight months of constant work, night and day, not a trace of oil can be seen on the pulley or belt.

Transvaal, South Africa. B. J. Lowe.

Engineers' Study Course

Elementary Mechanics--VII

Last Lesson's Answers

26. In Fig. 26, let the line ABC represent the given pole and let the pressures exerted by the men be represented by the forces P_1 and P_2. The resultant of these two forces is equal to $60 + 40 = 100$ lb. Hence the weight W, which is equal and opposite to the resultant, must equal 100 lb. This weight is located nearest the

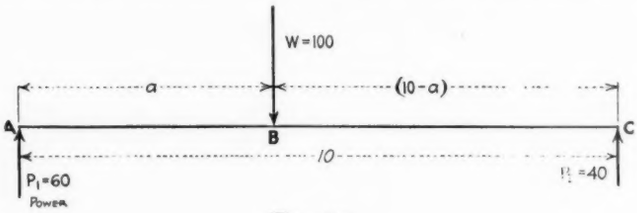


Fig. 26.

man supporting the greater load. The distance a may be found from the equation,

$$\frac{a}{(10 - a)} = \frac{P_2}{P_1}$$

or

$$a = \frac{P_2}{P_1}(10 - a) = \frac{40}{60}(10 - a)$$

$$= \frac{400}{60} - \frac{40\,a}{60} = \frac{20}{3} - \frac{2\,a}{3}$$

$$3\,a = 20 - 2\,a \text{ or } 5\,a = 20$$

hence $a = 4$ ft. and $(10 - a) = 6$ ft.

27. This problem illustrates a special form of couple: namely, a couple in which one of the equal and opposite parallel forces is produced by the reaction of a fixed bearing. Thus the pressure exerted by the man on the crank is one force, the distance from the center of the handle to the center of the shaft is the arm of the couple, and the second force is the reaction offered by the bearing, without the existence of which, the man could exert no pressure at all on the crank.

28. The moment arm equals 12 in., the force is 30 lb. and, therefore, the turning moment (more commonly called *torque*) produced is equal to $12 \times 30 = 360$ in.-lb., or 30 ft.-lb.

29. In this problem the force is 10 lb. and the moment arm is 24 in.; therefore the turning moment is

$$24 \times 10 = 240 \textit{ in.-lb., or } 20 \textit{ ft.-lb.}$$

30. The effective force tending to produce rotation of the crankshaft was found in problem 9 to equal 6000 lb. The moment arm of the force is the length of the crank which is one-half the stroke of the engine or $\frac{1}{2} \times 18 = 9$ in.

Hence the turning moment is

$$9 \times 6000 = 54{,}000 \textit{ in.-lb.}$$

This moment does not remain constant since the pressure of the steam on the piston varies and also the angle between the crank and the connecting-rod.

Principle of Moments

In the discussion on concurrent forces it was shown that, for a state of equilibrium to exist, the sum of the horizontal and vertical components must equal zero. In the case of nonconcurrent, or parallel, forces these conditions are not sufficient to insure equilibrium, for the sum of all the components might equal zero and yet there still might exist a tendency for the forces to produce rotation of the given body about a real or assumed axis. Hence the following additional condition must be fulfilled to produce equilibrium in a system of noncurrent forces:

When any number of forces acting on a body produce a state of equilibrium the algebraic sum of the moments of all these forces about any given point must equal zero. The converse of this rule does not necessarily hold true, for the sum of the moments might equal zero while there still existed either a resultant horizontal or vertical component through the point about which moments were taken.

It is to be noted that in the rule the term "any number of forces" was used without any statement being made as to the kind of forces—that is, whether concurrent or nonconcurrent. This means that the law applies equally as well to concurrent as to nonconcurrent forces, and in many instances problems can be solved more readily by moments than by the application of either the triangle or polygon of forces.

Thus in Fig. 16, Lesson IV, suppose the perpendicular distance from the point B to the line AC was 18 in. and the distance AB was 30 in. Take moments about the point B. The force P acting in the strut AB *can have no moment about the point B since the force P passes*

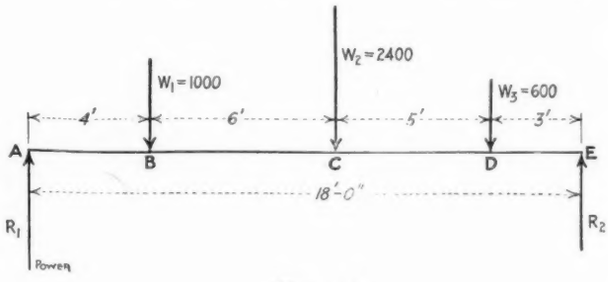


Fig. 27.

through the point B and as the moment arm is zero, the moment must also equal zero. The only forces, then, having moments about the point B are the tension T in the rod AC and the weight W acting at the point A. The moment of $T = 18 \times T$ and the moment of $W = 30 \times W$. From the condition of equilibrium previously stated the algebraic sum of these moments must equal zero, or $18\,T - 30\,W = 0$; hence

$$T = \frac{30\,W}{12} = 2.5\,W$$

For all problems involving either concurrent or non-

concurrent forces then the three following equations must always be satisfied.

$$\Sigma H = 0$$
$$\Sigma V = 0$$

(see equations (8) and (9), Lesson III).

$$\Sigma \, moments = 0 \qquad (10)$$

Since the resultant of a system of forces is a single force that will produce the same effect on a body as the combined action of the system it must be apparent *that the moment of the resultant is equal to the algebraic sum of the moments of all the other forces.*

A common application of this principle is in the determination of the reactions of the beam. In this case the pressure acting at either support or *pier* is the resultant of all the other forces. The beam remains at rest, due to the fact that the support exerts a reaction which is equal and opposite to the above resultant.

A practical application of this principle is made use of in the design of the main bearings of an engine. The load on each bearing can be found when the weight of the shaft and flywheel, the thrust of the connecting-rod, etc., are known, by taking moments about each bearing.

Problem: A beam of 18-ft. span carries concentrated loads of 1000 lb., 2400 lb. and 600 lb. at distances of 4, 10 and 15 ft., respectively, from the left end of the beam. The beam is supported by a column placed at each end of the span. Find the load on each column, neglecting the weight of the beam.

In Fig. 27, let AE represent the beam of 18-ft. span and W_1, W_2 and W_3 the respective loads located as stated in the problem. Let R_1 and R_2 be the reactions exerted by the columns. The load acting on the column at E is the resultant of the reaction at the point A, and the loads W_1, W_2 and W_3 The force counteracting this resultant is the reaction of the column at the point E indicated by the force R_2. For equilibrium the algebraic sum of the moments about any point must equal zero. Taking moments about the point A there results the equation,

$$R_1 \times 0 + 4 \times 1000 + 10 \times 2400 + 15 \times 600 - 18 \times R_2 = 0$$

or

$$18 \times R_2 = 0 + 4000 + 24{,}000 + 9000 = 37{,}000$$

hence

$$R_2 = 2055 \; lb.$$

In like manner taking moments about the point E there results the equation,

$$R_2 \times 0 - 3 \times 600 - 8 \times 2400 - 14 \times 1000 + 18 \times R_1 = 0$$

or

$$18 \times R_1 = 0 + 1800 + 19{,}200 + 14{,}000 = 35{,}000$$

hence

$$R_1 = 1945 \; lb.$$

The student should study these equations carefully so as to understand the use of positive and negative moments.

However, these equations do not fully satisfy the condition of equilibrium and the additional test of $\Sigma V = 0$ must be applied. From this law there results the equation,

$$-1000 - 2400 - 600 + 2055 + 1945 = 0$$

or

$$-4000 + 4000 = 0$$

Hence all the conditions of equilibrium are satisfied and the reaction of 2055 lb. at the point E and 1945 lb. at A will keep the beam at rest under the given loads. If any error had been made in the computation of R_1 and R_2 from the equations of moments it would have been discovered when the law of $\Sigma V = 0$ was applied.

After the student has acquired confidence in problems dealing with beam reactions he will find himself determining one reaction by taking moments, and then subtracting the reaction thus found from the algebraic sum of the vertical loads to find the remaining reaction. This is not to be commended as there will be no check on the work. If, however, moments are taken about each reaction and, if the sum of the reactions found from the equations of moments does not equal the sum of the vertical loads, it means that an error has been made and the necessary corrections may be made before proceeding farther in the design of the beam.

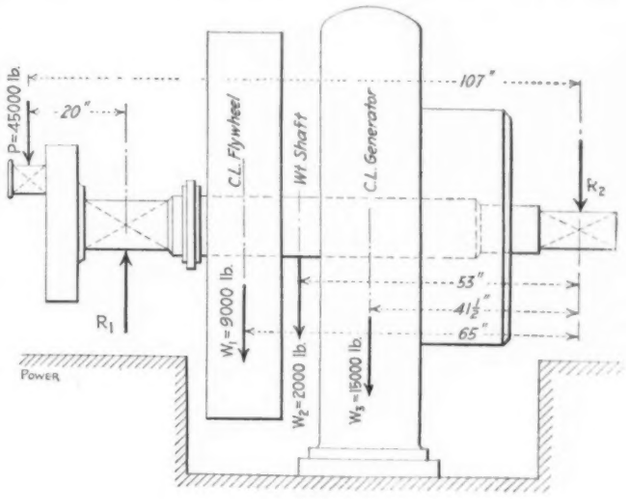


FIG. 28.

STUDY QUESTIONS

31. Fig. 28 is a diagrammatic sketch of the crankshaft of a vertical side-crank engine. The weight of the flywheel is 9000 lb. and acts at a point 65 in. from the right-hand bearing. The weight of the armature of the generator plus the magnetic pull is 15,000 lb. and acts at a point 41½ in. from the right-hand bearing. The thrust P on the crankpin is 45,000 lb. Assume the weight of the shaft as concentrated 53 in. from the right-hand bearing. Weight = 2000 lb.

Make a sketch showing the location of all the loads and the reactions.

32. Find the reactions R_1 and R_2 for the down stroke by taking moments about the points R_1 and R_2.

33. Find them for the upstroke in like manner.

34. Check the computations for 32 and 33 by making $\Sigma V = 0$.

35. At the instant shown in Fig. 28, does the pressure of the steam on the piston produce any turning moment on the crankshaft?

The World's Biggest Ocean Liner is to be built at Belfast, according to announcements in English newspapers. It will be of 60,000 tons, whereas the "Vaterland" is of 58,000 gross tons, the "Imperator" 52,171, the "Britannic" 50,000, the "Aquitania" 47,000, and the "Olympic" 46,369 tons. The "Britannic," launched at Belfast on Feb. 26, for safety, will have 48 of the largest lifeboats yet made, two of them fitted with powerful engines.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

You must print MY stuff just as it's wrote!"
Is what he said. And he got our goat.
All we could do was to send this note:
Dear Sir: Sit down; you're rockin' the boat!"

Hiram Charles asks us if apiculture is the rearing of apes. No, Hi; somebody is trying to make a monkey of you. Apiculture is the rearing of the busy little bee, and offhand, it looks like you'd been stung, honey. (The "Inquiry" editor turned this over to us as irrelevant. Mebbe he has the hives. —Editor.)

Down in Venezuela they call the native soft drinks "frescos." Just think, chief, of staying out until 8:07 p.m. frescoing your town, and then hurrying home to put a dado around Fido's domicile or a frieze on the rooster's bungalow. Great sarsparilly!

Once upon a time there was a little boy who—oh, here, read it yourself!

"A little boy invented the safety valve for engines. It was his business to watch the steam pressure and let the steam off when the pressure got too high. But he wanted to play at marbles and other games free from worry. And he invented the pressure, the whirling apparatus on the top of the steam engine, which, by the power of centrifugal force, wedges apart the two revolving balls and lets the steam escape automatically when the pressure gets too high.—Editorial in "Chicago American."

Oh, piffledinks! Why didn't this editor let little Archibald keep on playing at marbles; then he wouldn't have had all this trouble with his "whirling apparatus"?

You-all, one time or another, have been amused by the factory picture that looked like it covered 149 square miles, had a forest of stacks belching volumes of dense black smoke, and a million windows, and apparently housed 65,432 employees? One concern has already been driven to say under its illustration: "All buildings here shown are part of our works." Good scheme, and enlightening.

A fire was recently caused by wire bed-springs short-circuiting a storage battery temporarily placed under the bed, says "Electrical World." The occupant sitting on the bed made the springs sag and short-circuit the battery terminals so that the wire fused, burning a hole in the mattress and setting fire to the bedding.

Here's an idea for an inventor of an old maid's patent burglar alarm; that is, if it's still true she's looking under her bed for burglars.

A Nevada miner has suggested this "safety first:"

"To the Safety Department. How to prevent accidents: Close the ——— ——— saloons.

"ROASTER PLANT."

The saloons in Dublin Gulch, says the "Engineering & Mining Journal" have the "peculiarly exasperating practice" of furnishing beer chasers. This is the best reason yet for a "dry" town. If the teetotalers love a shining mark, Dublin Gulch is a barndoor target.

Woman of 114 Attributes Age to Never Having Worried.—Headline.

Like to know how to prove a case like this. Looks as if we'd have to begin with our grandchildren, and this would start some of us to worrying right off the handle.

"Starve the railroads and we starve ourselves," says Frank Munsey. There's no getting away from it, we need the railroad if we want to get anywhere, and in the cities it brings us our eats. Two good reasons why the railroad has some rights we are bound to respect.

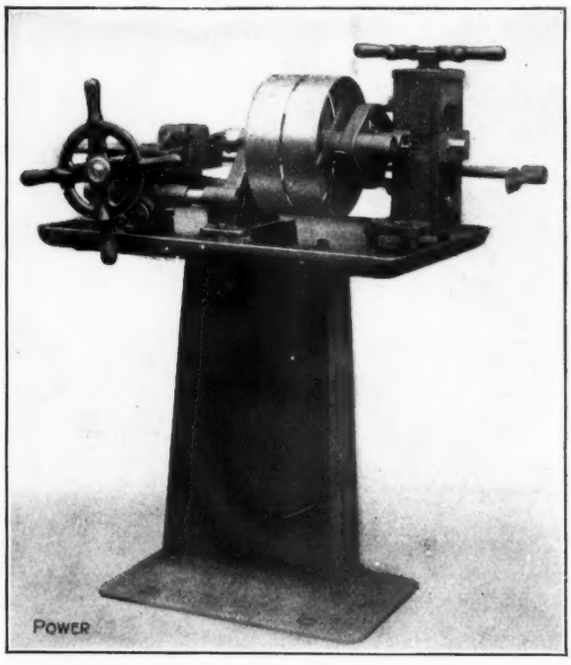
He "has light complexion and hair and sharp features" is a contemporary's partial description of an engineer impostor. Is it unusual for an impostor to have hair? Whatcha mean, "and hair"? Are just baldknobs honest? And don't you believe a baldhead never goes crazy. They're all crazy—to grow some hair. And hair! Why not tell how many? An easy task for those who are coaxing a few on very evident false pretenses.

Oster Cutting-Off and Reaming Machine

This machine is designed to cut off and ream pipes in all sizes up to 2 in. in diameter. It is provided with a large single, stationary wheel tube cutter mounted on a steel pinion which rests in a bronze bearing.

The pipe to be cut off rests on a pair of rollers, and by a turn of the handwheel at the top of the machine, the pipe is brought in contact with the cutting disk and is quickly severed. A slight pressure on the handwheel regulates the speed of cutting off.

The two rollers which support the pipe while cutting off are made of steel and revolve in tempered-steel bear-



OSTER CUTTING-OFF AND REAMING MACHINE

ings. The rollers which support the pipe rest on the bottom of a yoke which slides up and down in the frame. The disk cutter can easily be removed for sharpening or renewal. The gage rod is adjustable for the different lengths of pipe to be cut off.

In reaming, the pipe is held in the vise jaws, which are opened or closed by a movement of the handwheel at the side of the vise. The open vise enables the operator to quickly change the work.

Pressure of the pipe against the reamer is brought about by the handle mounted behind the vise wheel, which moves the vise back and forth. The vise is solidly mounted on this frame.

The reamer is held fast by a setscrew: it can be easily removed for sharpening when necessary.

This machine is built by the Oster Manufacturing Co., Cleveland, Ohio.

Winnipeg (Man.) Owns Its Public Utilities, among which are the electrical works, at Point du Bois on the Winnipeg River, 77 miles northeast of the city. The waterfall, naturally 32 ft., has been increased by the power-development dam to 47 ft., with a pond of 6000 acres. The total power available, without storage, is 60,000 hp., which can be increased to 100,000 hp. These works, including generating stations, completed and equipped, cost Winnipeg $5,000,000.

Fuel Pumps and Compressors of Oil Engines

By Frank E. Booth

Heavy oils when used in oil engines are atomized by means of compressed air; hence the continuous and satisfactory operation of the engine depends largely on the oil pump and air compressor.

Oil Pump

The oil and air pipes are both directly connected with the atomizer. The air pressure may be anywhere between 300 and 1200 lb., and a little dirt on the check valve of the oil pump may cause it to refuse to deliver against this pressure and cause a shutdown. For this reason, the fuel should be run through a screen before entering the oil-supply tank. Multiple check valves in series reduce the liability of shutdown from this cause as the chances are that both valves will not be fouled at the same time.

Furthermore, there should be no air pockets or traps in the interior of the pump as air bubbles will interfere with the operation of the pump. If the pump plunger is worked by hand, a spring effect caused by air bubbles is quickly detected. A stroke with uniform pressure from start to finish indicates an absence of air.

If the engine has been shut down for some time, air may get in the suction pipe and make it impossible to start. A bypass connecting the discharge pipe with the suction and having an air chamber in the line, may be used for freeing the pump of air. When operating the pump by hand with the bypass open, the air lodges in the air chamber and is liberated through a petcock at the top.

The oil is likely to carry in suspension a certain amount of water, and when the engine is shut down this water accumulates at the bottom of the oil tank; if it is not drained off, the engine will miss fire when starting. The pipe should enter the oil tank three or more inches from the bottom and a faucet should be placed near the bottom to take care of the water.

Candlewick rubbed well with soap and graphite makes a good packing for the pump plunger. The pipe joints may be made up with litharge and glycerin or shellac. Moreover, the oil pump should have surplus capacity to take care of any small leaks which might occur during operation.

Air Compressors

A two-stage tandem air compressor has pressure behind the piston all the time, making a smoth-running machine by keeping the slack in one direction. There should be some adjustment endways so that the piston clearance may be kept at a minimum and the valves should be caged so that a duplicate one might be inserted at short notice.

A little soapy water fed through the low-pressure inlet helps to keep the valves clean. Too much lubricating oil will foul them as it chars with the heat, the carbon thus formed causing the discharge valves to stick. Sometimes too much oil also causes explosions in the compressor.

If the low-pressure inlet of the compressor be coupled to the air-inlet pipe of the engine, the compressor will make very little noise. A safety valve should be placed in the air line between the compressor and the tank. This relieves the pressure should the tank valve be closed by mistake. It may be noted that when the compressor is in good order, the low-pressure discharge pipe is not as hot as the high-pressure, which fact helps one to locate trouble. If the high-pressure discharge valve is leaking, the low-pressure discharge pipe will be much hotter than usual; the low-pressure discharge pipe is not hot when trouble exists in the low-pressure end. A pressure gage on the intermediate receiver will also help to locate trouble.

Sometimes the compressor is working all right when the pressure gage indicates a loss. This may be due to a leak in the air line, a leak in the sprayer valve proper or around the valve spindle; moreover, the sprayer valve may stay open too long, caused by too great a lift or too long a contact with the cam.

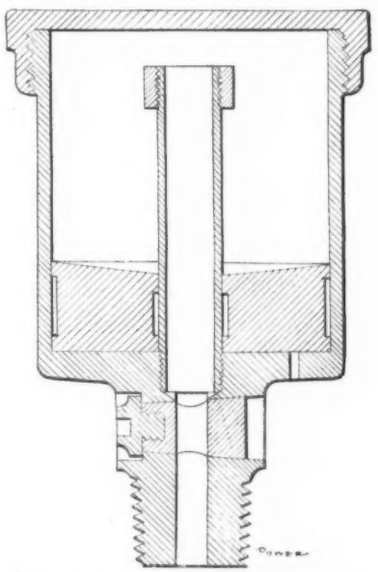
If one cylinder in a multicylinder engine cuts out, which sometimes happens on light loads, the reduced pressure in the cylinder allows more spraying air to go through the valve. Also, an engine valve not seating properly causes reduced compression and lower initial pressure with a loss of spraying air.

*

Organ Centrifugal Grease Cup

This centrifugal grease cup is used primarily for loose pulleys and thrust bearings, the grease feeding through the cup only when the bearing is moving.

It consists of a shell threaded at the shank on the lower end to fit in the hub of the pulley. The top is a cap which screws onto the cup. On the inside is a piston which slides on a stationary tube, capped at the top with



Section of Organ Grease Cup

a stop nut. In the shank is a regulating plug for controlling the feeding of the grease.

In operation, the centrifugal force presses the movable piston against the grease, causing it to flow through the center tube to the bearing. When the cup is empty, the cap is removed and the cup filled with grease on top of the piston. This cup is made by the Keystone Lubricating Co., Twenty-first, Clearfield and Lippincott Sts., Philadelphia, Penn.

Selection of Refractory Materials

By Morgan B. Smith

SYNOPSIS—An outline of tests to determine the quality of firebricks and fireclay.

The purpose of refractories for power-plant use is a problem which every purchasing agent or chief engineer has to solve sooner or later in the course of operation. In this problem two factors are prominent, namely, the utility for which the refractory material is to be purchased, and, secondly, the refractory itself. The utility is, of course, predetermined by the purchaser; the general essential characteristics of the required refractory are known; the question then is to find a refractory which possesses these requirements.

The tests which a purchaser may make follow certain well defined lines in which the essential characteristics are brought out under conditions closely simulating those of practice. As a matter of fact, it is always good policy to maintain the conditions of the tests somewhat more severe than in practice for the customer is wise in insisting on a certain margin in the way of service from a refractory material, i.e., he has the right to demand materials somewhat better than the utility actually demands.

Inasmuch as refractory materials, firebrick and fireclay, are used in power stations mainly for the linings of the combustion chambers and arches of boiler furnaces, the tests which have been found essential will be outlined.

Measurements

General dimensions in inches (or centimeters), accurate to $\frac{1}{32}$-in., should be taken. From these figures the volume is figured and the relation between the volume found and that of a standard brick of the same shape established. From this ratio the estimating engineer can figure the amounts necessary for the given utility.

Calipered measurements are to be taken before and after heat tests of length, breadth and thickness, each dimension being taken at two different points so as to assure a fair average in the measurements. These figures give the change in size, due to heat tests, or, in fact, any tests which may tend to distort the shape of the firebrick. Change in size is one of the best indications of the future behavior of the firebrick under practice conditions, especially if this information is combined with that obtained from the load test given below.

Weight

The weight is of importance as a rule to the constructing engineer as it gives him an idea as to the mass to be carried by his structural work and indeed by the refractory itself. The weight figure is also of use in figuring the density of the material. This is generally taken in pounds and ounces, but may be in kilos and grams if greater accuracy is desired.

Porosity

This is generally determined by determining the amount of water which the brick will absorb in a given time. It is also a measure, indirectly, of the density of the material; also of the degree of "burn" and, in a measure, of the load-carrying ability.

High-Temperature Tests

In these tests the temperature must be somewhat higher than that to which the refractory would be subjected in practice and must be maintained over a considerable length of time in order that all the characteristics of the material sensitive to heat may be developed and the phenomena noted. All the conditions of practice should be duplicated insofar as is practicable, including the action of coal ash, coal gases, clinker, etc. Such tests can be run along with the simple heat tests in the same furnace and consist of burning the coal to be used in the boiler furnace on top of the firebrick being tested, the coal being renewed as fast as it burns away. In this way the tendency of the firebrick and ash or clinker to react and flux each other may be noted. The author has found that very often a refractory which stands up under the high temperatures splendidly, fails utterly when maintained at the same temperature in contact with coal ash or clinker.

Pyrometry of Heat Regulation

In high-temperature tests it is absolutely essential that the temperature be determined and maintained by means of some form of accurate pyrometric control. This is so because of the desirability of being able to duplicate conditions in check tests and also because of the fact that the accurate evaluation of the refractory demands it. For moderate temperatures, not exceeding 1000 deg. C., the platinum-resistance thermometer is probably the ideal outfit, although there are so called base-metal pyrometers which are satisfactory under general conditions. The latter have one advantage over the former type, namely, that they are fairly accurate at the lower temperatures and may also be used at temperatures higher than the former type will stand.

For high temperatures, up to 1550 deg. C., there is a choice between two types, the platinum-platinum-rhodium couple and the radiation pyrometers. The latter is too delicate an instrument for general use around power stations and the extreme temperature range of this instrument is not required for such work. The platinum-platinum-rhodium couple with its sensitive indicator must be calibrated from time to time against the known temperatures of metals or salts, a list of the more common points being given below.

Element	Melting Point, Deg. F.
Tin	450
Cadmium	610
Zinc	786
Antimony	1166
Aluminum	1216
Calcium	1481
Barium	1562
Silver	1762
Gold	1945
Copper	1981
Nickel	2642
Palladium	2822
Platinum	3191
Tungsten	5432

From the above elements a selection may be made according to the range of the tests in question and the pyrometer standardized accordingly. It is best to select

points covering a fairly wide range, for then the temperature curve of the pyrometer will be more nearly correct than if only a few, closely related points are taken. The zero for the couple is taken at the temperature of melting ice and the cold end of the couple must always be used at the same temperature as when the zero is established or else somewhat uncertain corrections must be made. If possible the cold end should be either water or steam jacketed to assure a uniform temperature.

There are also the older pyrometric indicators, such as the Seger cones, which give good results when only momentary temperature indications are essential. As a rule, they are accurate when used properly, they must not be allowed to soak at temperatures lower than that which they are supposed to indicate for they will almost invariably bend under such treatment and so indicate a temperature really higher than exists. They should be heated up carefully outside of the furnace where they are to be used and, when thoroughly heated through, should be inserted into the test furnace. They will then come quickly to the temperature of the furnace and will not give false indications. The author has noticed, for example, that the cone which indicated 1370 deg. C. under normal treatment gave just as good an indication when held at 1320 deg. for a comparatively short time. With a little practice the use of the electro pyrometer and the cones may be combined to good advantage as the cones serve as a ready check on the accuracy of the pyrometer during a test run.

Load Tests at High Temperatures

These tests are essential, for they give the real capacity of the firebrick to stand up under load at high temperatures. It is frequently found that a brick which is strong at ordinary temperatures becomes easily crushed and often will bear no load at all in proportion to that which it must carry in practice when heated to a high degree. There are two ways of conducting such a load test, namely, by testing a single brick and by testing a mass of the test bricks generally laid up in the form of a pier.

In the first case the test brick is supported above the floor of the test furnace by the ends and is weighted in the center on top with a weight proportional to the load which the brick must carry in practice. In the second case no load is added unless it is necessary to do so to bring the load up to that found in practice. The pier is built in the furnace, projects through the roof and carries its load (if any) upon its top. Measurements of the pier before and after the test give a measure of the load-carrying capacity of the brick in question.

In general practice around power stations the test on single bricks has been found satisfactory, especially if always carried out on some particular standard shape, such as an ordinary 9-in. straight, as then all tests become comparative. For general utilities a 9-in. straight firebrick should be supported on two soap bricks 2¼ in. off the floor and 7 in. clear of supports. This gives the brick 1-in. bearing at each end. The weight used is generally 7.5 lb., made by trimming a magnesite, or better, a chrome firebrick. The load, however, as stated above, must be determined in proportion to that carried in practice. Many an arch failure might have been averted had such a load test been carried out at or near the temperature maintained in practice.

Abrasion Tests

It is not often that these tests are conducted on refractories used in boiler furnaces, but there are certain phases of this test which are of value, especially where firebrick are used in the linings of furnaces heated with inclined grates, such as the Roney, where there is at times severe abrasive action, due to the constant steady motion of the fuel down the grates and along the brick surfaces. Such tests should be carried out at as high a temperature as is practicable since the resistance to abrasion varies with the temperature of the brick.

An apparatus for abrading firebrick may be made by studding an iron or steel plate with many soft-iron stove bolts, or similar material, which may be renewed from time to time as they wear away. The plate is drawn back and forth over the surface of the brick a definite number of times and the material worn away weighed. It is also possible to apply the rattler test, commonly applied to building and paving brick, to firebrick with good results if the firebrick are hard burned and fairly close grained.

Shock Tests

These tests are carried out to determine a firebrick's resistance to sudden changes in temperature. The firebrick is heated to the desired temperature, is withdrawn from the furnace at full heat and is immediately plunged in cold water or buried in wet, finely ground coal. It is then removed from the water or coal and examined, after which it is again heated and chilled if desirable. A firebrick should stand this test without checking or spawling. The test simulates, in a degree, the conditions in a boiler furnace when fires are banked quickly or when the boiler is taken off of bank and the fires are brought up to full intensity in a short period of time.

Firebrick vs. Fireclay

Needless to say it is of great importance in laying up firebrick to know what may be expected of the fireclay with which bonds are effected and joints made tight. A fireclay, to fill its utility, must make good bonds between the firebrick and must produce permanently tight joints. It must do this without inducing undue fusion in the firebrick and must not fuse unduly itself.

A good way to test out a fireclay is to lay up the two halves of a split 9-in. firebrick, as in practice, with the clay in question, rubbing down joints carefully. This test piece is then heated to the desired temperature for a stated length of time and results noted. As a rule, the fireclay should be of a slightly lower degree of refractoriness than the firebrick with which it is to be used. This statement is made, however, with caution, for it is only by test that the proper degree of refractoriness of a fireclay can be determined for use with a certain brick under certain conditions. It is well to remember that the less fireclay used the better, so long as the desired function of the clay is attained.

Physical Tests

As a rule, physical tests, such as resistance to crushing load, are not applied to firebrick used for furnace construction. Some data may be obtained, however, in special cases which is of value, but the fact must be kept in mind that temperature plays a large part in tests of this character and the results of these tests at ordinary

temperatures must be considered along with the load tests at high temperatures. At best, physical tests at ordinary temperatures are a measure of the general workmanship, the degree of burn and the condition of the bonding of a firebrick.

Heat Conductivity

In the case of boiler-furnace refractories, heat conductivity is not desired, rather the reverse, for it is by reflection of heat that the gases of combustion of coal are ignited. It is equally true that those bricks which show a comparatively low degree of conductivity give the longest service. As a matter of fact, the brick composing the lining of the combustion chamber should also show a low degree of conductivity so that the radiation losses may be cut down as much as possible.

Heat conductivity is best determined by the calorimetric method in which the heat imparted to a known volume of water is measured over a stated period of time. There are other methods in which the penetration of heat into a firebrick is measured by inserting pyrometric couples into the brick to varying depths and the temperatures noted. In such tests one end of the brick is maintained at a definite temperature, the pyrometer couples indicating the fall in temperature away from the hot end of the brick. These tests are purely comparative, and do not give the actual conductivity.

General Data

Under the heading General Data may be included notes on the following characteristics: Workmanship; degree of burn; indications of the presence of fluxes, such as alkalies, ferrous iron, titanium oxide, etc.; size of grain, its compactness or looseness; tendency to spawl or otherwise; surface checks or cracks; conditions of the "skin"; behavior when cut, its tendency to ravel or otherwise; the condition after heat tests and load tests at high temperatures.

Analysis—Ultimate and Rational

The ultimate analysis is of value in that it affords the opportunity to calculate the probable degree of refractoriness by the so called "Bischoff number," in which case the refractoriness is referred to the relative proportion of the silica, alumina and fluxes found by analysis, according to the formula:

$$a\ Al_2O_3 + b\ SiO_2 + RO$$

where RO is taken as the unit representing the fluxes, a and b indicating the amount of alumina and silica in proportion to the fluxes. Bischoff suggests that the degree of refractoriness be shown by the formula: a^2/b, that clay which gave the highest "number" by this formula to be considered the most refractory. This method is somewhat uncertain, for some clays give figures which correspond well with the direct fusing tests, whereas others do not.

The rational analysis, in which an attempt is made to separate the clay into its mineralogical constituents, is of value along with the ultimate analysis when carried out properly. It requires much experience to get accurate results.

The tests, as outlined above, will give satisfactory results when conducted with care and with a proper sense of the character of the refractory and of the utility. The best test of a refractory in the long run is its actual use for the given utility and whenever possible such practical tests should be conducted.

Alberger Multihead Heater

When heating feed water from 40 or 50 deg. to within a few degrees of the temperature of the steam, the most severe treatment the heater gets is when it is placed in service after being cold, at which time the tubes are all of one length. There will also be an unequal elongation of the tubes, due to the change of temperature which, unless taken care of, creates strains in the tubes and tube heads.

An effective design of heater has recently been developed by the Alberger Heater Co., Chicago and Granger

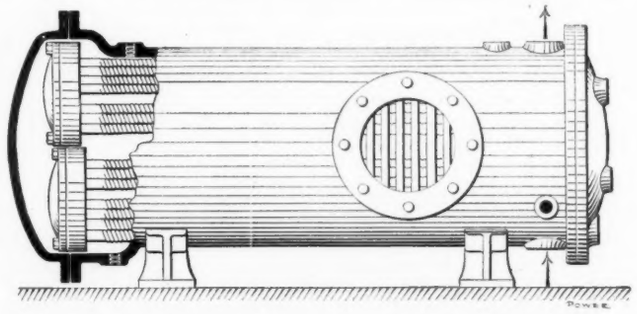


Fig. 1. Heater with Double Floating-Tube Heads

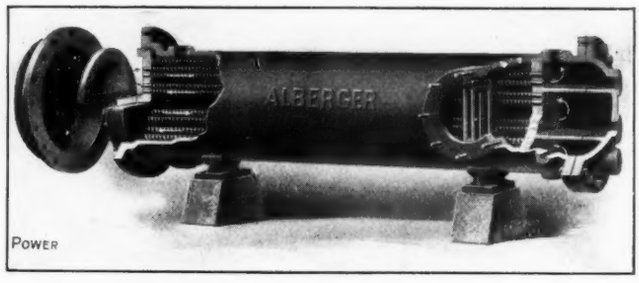


Fig. 2. Multihead Water Heater

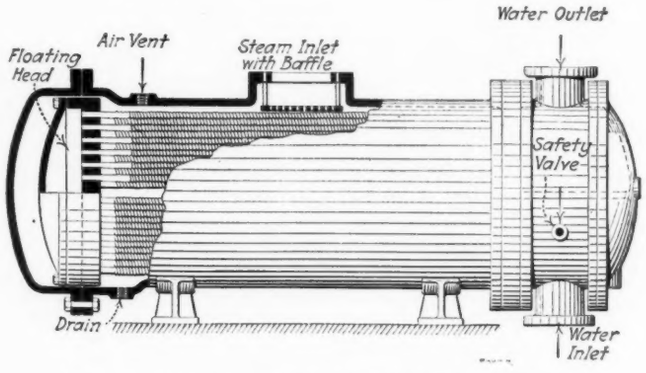


Fig. 3. Single Head in Two-Pass Heater

Sts., Buffalo, N. Y. Several groups of tubes are permitted to expand or contract free from each other, by means of floating-tube heads which hold the tubes containing hot water. The heads may assume a position, say, ¼ in. further away from the stationary-tube head at the opposite end, than the floating-tube head holding the tubes which contain cold water (Fig. 1), and no

harm can result from the unequal expansion or contraction.

In Fig. 2 is shown a design for heating boiler-feed water wherein a multihead design is used. It is of the four-pass construction. The right-hand tube head is secured to the shell, but the floating-tube heads at the opposite end of the shell are free to move independently. The tubes are expanded at both ends into the tube heads and no packings are used. The cold feed water enters at one end of the heater at the bottom and passes through it four times in the direction of the arrows, discharging at the same end and at the top. As all steam and feed connections are made directly on the shell it is not necessary to break these pipe connections to obtain access to the heating surface for cleaning or inspection. All heaters are supplied with baffle-plates to protect the tubes from the impact of the incoming steam, and assist in distributing the steam over the heating surface.

The hot-water service or domestic supply heater, such as is used in hotels, hospitals, etc., follows the same construction. As the service this heater is required to perform is unusually severe, the multihead arrangement should be used to prevent trouble.

For the forced-circulating heating system the water is usually passed through the heater twice because of the large quantity of water to be handled, and as the temperature range, usually from 20 to 25 deg., is very small, the multihead arrangement is not necessary. In such a heater a single floating head is used, as illustrated in Fig. 3.

In all heaters a seamless-drawn copper tube, which is 99.8 per cent. pure copper, is used. The corrugated tube was adopted in order to obtain a high rate of heat transmission. The corrugations are not depended upon to take care of the expansion or contraction. All tubes are expanded rigidly into the tube heads.

The induction or dead-end principle is used largely, although a steam-outlet connection can be furnished if the conditions demand. The heater is made in either the vertical or the horizontal type.

Boiler Inspections*

By S. F. Jeter†

The present-day "safety first" movement has apparently take all by storm, but if full credit is to be given where credit is due, it must be remembered that boiler inspection was the first "safety first" movement. It is the first duty of the boiler inspector to endeavor to prevent accidents to the boilers under his care.

He must, of course, know boilers thoroughly; so well, in fact, that he feels confident his recommendations or demands are absolutely right. His backbone must be without joints when it comes to arguing a case regarding changes that are necessary for safety.

He should be built like a camel, gastronomically, and learn to eat and drink when he reaches a point where food may be obtained. These requirements do not particularly apply to New England inspectors; in the West and South it is a real and necessary qualification. Boiler inspections are divided into two general classes, usually termed external and internal, but the names would better designate their nature if they were called operating and general inspections. The external is usually made without any previous notice to the assured, and the inspector's duties in connection with this inspection are such that the operation of the plant is in no way interfered with, providing, of course, everything is found in order.

To make an internal inspection, it is necessary that the boiler be idle and empty and that the manhole and handhole plates be removed as well as otherwise prepared for examination. I will first describe the internal or general inspection because the first of such inspections is the one required for the approval of the risk for insurance, and I can assure you that finding the boilers is sometimes no mean part of the inspector's task.

On arriving at the plant he usually meets the chief engineer and other plant attendants. At this meeting the inspector's ability to size up his man is most necessary, because the plant employee can make his task difficult or otherwise, as he may see fit, and he also can be of inestimable value in imparting information regarding operating conditions which the inspector could not hope to obtain in any other way. Often a minor accident has resulted in the injury or death of an employee—causing mental anguish as well as physical pain, and, besides, an expense to the assured or insuring company which could have been prevented by providing reasonable means of exit.

The blow-off connection is a fruitful source of such accidents. The blow-off valve is frequently so placed that the man operating it is in a closely confined space, with the piping so arranged that a break at any point during the act of blowing off is likely to cut off all means of his escape. It is the inspector's duty to recommend the necessary changes required to prevent such an occurrence. The steam and water piping, as a whole has to be carefully considered to see that there are no connections which may lead to accidents or dangerous conditions of operation. The feed appliances, such as pumps, injectors, etc., and the piping between them and the boilers, must be inspected for safety as well as general plan and capacity, so that the boilers may at all times be supplied with an abundance of water to meet their maximum capacity.

SOME FIRST THINGS TO EXAMINE

With separately set boilers the connecting pipes to the water space must be examined to see that it is separate and distinct, with check valves properly arranged to prevent the transfer of water from one boiler to another. In some cases, where the heating plants work on low pressures and gravity returns, it is found best to do away with check valves between the boilers. The steam pipe must be so arranged that no pockets will be formed to trap the condensation and it must also be so connected that the movement due to the expansion and contraction can take place without undue strain on any of the parts. Many lives have been sacrificed owing to a lack of precaution and forethought in suitably arranging steam piping.

An examination must be made of the connections and attachments for determining the water level, for it matters not how strongly a boiler is built if the water line is continually carried even a small amount below the fire line; disaster is almost certain to follow sooner or later. Water columns are frequently found set so low that the safety of the boiler is endangered. The blow-off or drain connection from the water column is examined to see that its size is ample. The connection from the steam space of the boiler to the top of the water column must be inspected to see that there are no connections on this pipe that are required to furnish a supply of steam for any other apparatus, or that water can be trapped in the pipe. Either of these conditions will render the indications of the water level inaccurate. Whether the location of the steam gage is correct must be determined; frequently it is so connected to a boiler that the steam comes in direct contact with the spring or it is so fastened that it is exposed to heat from some part of the boiler or smoke flue, either of which conditions renders its indications inaccurate. The safety valve is a most important attachment and deserves the closest scrutiny to determine its condition. The escape pipe from a safety valve is another frequent source of danger, and the inspector must see that it is properly drained and well supported to prevent undue strain on the valve.

*Abstract from a paper read before the Insurance Institute of Hartford, April 7, 1914.

†Supervising inspector of the Hartford Steam Boiler Inspection & Insurance Co.

If the boilers are of the suspended type, the ability of the supports to safely carry the load must be determined. This usually requires complete data of columns and supporting members as well as sizes of hangers, etc. The determination as to whether each support is carrying its proper proportion of the load is necessarily made, for proper boiler support is just as important as regards its safety as is its strength in any other respect.

THE INTERNAL INSPECTION

The inspector, after writing the answers asked on his data slip regarding the various parts examined so far, then enters the top manhole with a light, a rule, calipers, a hammer and usually a depth gage. He first carefully examines the condition of the parts; the shell may show evidences of pitting, especially along and just below the water line; the tubes may be pitted or thin from general corrosion; the braces may be weakened by corrosion or they may be loose, due to strain or improper fitting. The soundness of the braces is usually determined by striking them with the hammer as well as by visual inspection, and the shell is carefully sounded to determine if there are indications of cracks or laminations in the shell material. Many of the rivets are sounded for tightness. The condition of the upper portion of the boiler as regards scale or oil deposits is ascertained, and it is not uncommon to find the spaces between the tubes against the rear heads completely stopped with scale for a foot or more. Such conditions are likely to lead to serious trouble, if not explosion. Any indication of oil in a boiler is a serious matter; there is no substance likely to reach the interior of such a vessel that can produce an effect at such wide variance with the apparently harmless nature of the cause.

All openings to outside attachments or connections are examined to see if they are free, as many boiler explosions have been caused by a stoppage of the water-column connection. Where the connections are supplied with a pipe screwed into a part of the boiler or into a flange riveted to the shell, the inspector must note whether the screwed joint has been fully made. Since this inspection is assumed to be the first one made of the boilers under question, the inspector must obtain the necessary data for calculating the strength; he must know the distance between the shell and the tops of the tubes to correctly estimate the amount of bracing required; he must know the number and the size of the braces at their least section on each head. The number and the size of the rivets attaching the braces to both the head and the shell must be known so that the weakest element in the construction can be taken into account in calculating the strength. The thickness of the heads must be ascertained in order to estimate the strength of any unstayed surfaces and to judge whether a suitable bearing surface has been supplied against which the tubes were expanded. The pitch and the size of the rivets must be obtained as well as the design of the joint, so that its strength relative to that of the solid plate may be determined.

The size of the rivets is usually judged from the dimensions of their heads. The thickness of the shell, which must be known, can usually be measured by means of a depth gage applied along the edges of the plate at the girth seams, and may be calipered at an opening in the shell. If there is a dome, the details regarding the bracing of the head as well as those of the connection to the shell must be secured as well as the dimensions of the reinforcement around the opening from the boiler to the dome should this opening be large.

Upon coming out of the boiler, the inspector can place the data obtained on the data slip, but he usually waits until after completing his inspection. The layman might think it a difficult feat to commit all of these measurements to memory, but the average inspector can generally repeat offhand the principal data of a boiler several weeks after taking it.

The next point to be examined is the interior below the tubes if the boiler is supplied with a manhole communicating with this part of the structure. The usual points to be given attention here are the soundness of the bracing, the condition of the shell as regard corrosion or other defects; the heads and tubes, and to note the quality and quantity of the scale attached to the surfaces. Quality of scale is just as important as quantity as regards its ability to injure a boiler or detract from its economical operation. The tube-cleaner salesman and the boiler-compound man frequently quote tables giving the different efficiencies of operation due to fixed thicknesses of scale is boilers. While there is more or less regular change in the efficiency of a boiler with carrying thicknesses of scale of the same quality, it is pure buncombe to state that a given thickness of any kind of scale will reduce the efficiency a fixed amount.

Proper makeup of the blow-off pipe is determined while the inspector is in the lower part of the boiler. If there is no manhole below the tubes, the information just specified is determined as well as possible while in the upper part of the boiler, and also through the hand holes, which are usually supplied in the front and rear heads.

After completing the internal inspection, the inspector should examine the front heads externally. Here corrosion of the head and the tube ends is likely to occur, especially if the boiler is fitted with a stack connected directly to the extension sheet, for under these conditions rain may come down the stack during idle periods, and the sulphur deposit in the stack and on the head from the furnace gases, combined with the moisture, causes extremely rapid corrosion. The inspector must next examine the front to determine that no weight of the boiler is carried on it, unless it should happen to be one of the type, now rapidly disappearing, which is designed to carry the weight of the front end.

EXAMINING THE FURNACE

The inspector next enters the furnace and notes the condition of the fire sheets and the seams, and he should make a careful examination of the surfaces to locate any brands or stamps placed on the sheets by the manufacturers, and from which the tensile strength of the plate can usually be obtained. If rivets leak, it is the outside of the boiler that usually reveals this fact, and when leakage is discovered its cause has to be ascertained, so that necessary recommendations can be made. Leakage of the girth seams can be caused in many ways; if from scale or oil deposit, the inspection of the interior already made will generally reveal the cause. Poor workmanship will usually be evident to the experienced inspector.

The location, the shape and the size of the bridge-wall which forms the rear limit of the grate surface is often the cause or contributes to leakage at the girth seams. In many types of boilers the improper support is also a contributing cause. Feeding in the bottom of the boiler through the blow-off connection is another fruitful source of such trouble. The inspector must examine into all of these phases and must recommend the necessary changes.

The inspector must keep a sharp eye for evidences of leaks coming from the vicinity of longitudinal seams, as any such leak must be regarded with the gravest suspicion as the cause is likely to prove a hidden crack. This defect has been responsible for some of the worst explosions in the history of steam boilers and no leak at a longitudinal seam should be considered harmless until it has been so proved.

The condition of the setting walls must be known to the inspector, particularly with respect to their ability to properly support the boiler. The blow-off pipe should be examined to see that it is sound and free at the bottom—that is, that no weight is resting on it. This is a common source of accident. The freedom of the blow-off pipe where it passes through the setting wall is also essential to safety, as is the proper protection of the pipe from the direct impingement of the flame and the highly heated gases from the furnace.

The rear tube ends must be examined for leakage and for corrosion, and if the defects are disclosed, the cause must be determined and the proper recommendations made. The condition and the position of the covering over the rear combustion chamber must be examined into, as the arches generally used at this point are frequently located so high as to cause the overheating of the head above the water line. The fusible plug which is located in the rear head must be inspected to see that the fusible metal is in proper condition to respond to an increase in temperature should low water occur. After examining the blow-off valve and the outer portion of the pipe, the inspector is ready to test and, if necessary, to correct the steam gage. Then the inspection is completed.

After the inspection the inspector usually discusses the various points revealed by his examination with the chief engineer, and directs him in regard to the making of repairs or to the betterment of operating conditions. Inquiry should be made as to the maximum steam pressure required to properly operate the machinery used in connection with the plant as this should be given due consideration in fixing the maximum pressure to be allowed.

THE EXTERNAL INSPECTION

While the external inspection is not nearly so complete as the internal, it is, notwithstanding, a most important inspection. Operating conditions can be observed at such an inspection and dangerous practices stopped before it is too late to check their effect on the boilers. The inspector has a card or list indicating the allowed pressure on the boilers to be inspected, and on entering the boiler room he should note the gage pressure carried, and whether all the gages register alike.

The water column must be blown down to determine the freedom of the connections leading to the column, this being

made readily evident by the speed with which the water returns to its original level as well as the behavior of the water in the gage glass if the boiler is steaming. The gage cocks should be tried to see if they are free and in operating condition. An examination is next made of the fire surfaces of the boiler and the conditions of the furnace walls, as far as can be ascertained from the furnace doors. Notice is also taken of any tendency toward leakage or bagging or blistering of the plates. The front flue doors are opened in order to view the tube ends, which are examined for leakage and general conditions.

The rear of the boilers is now to be visited and the condition of the blow-off valve and connection is determined as far as their operating condition is concerned. There is frequently a cleaning door in the rear setting wall in such position that the fire surfaces and possibly the rear tube ends may be examined from this point.

The inspector next visits the top of the boilers and, ascertaining the steam pressure at the time, he tries the safety valves or has the engineer try them. With a safety valve of either the spring-loaded type or of the ball-and-lever design, and with the steam pressure not over 20 per cent. less than the pressure for which the valve is set, an accurate idea of the pressure at which a safety valve will operate can be obtained by testing the freedom of the valve by hand. If the safety valve does not appear to be properly adjusted, the inspector requires that steam be raised until the valve operates in the regular manner or until the increase in pressure positively demonstrates that it is set for a pressure in excess of the limit allowed.

One of the most important features regarding the external inspection is the discussion of plant conditions with the employees, for information of the greatest value, both to the assured and the insuring company, is often obtained in this way.

The mistakes of the inspector always stand out in bold relief after an accident, as does the soundness of his advice when compliance with his recommendations and demands can be assumed to have prevented the accident, but how many explosions are prevented by timely warning and advice can never be known.

In conclusion, I say that the subject allotted to me is so broad that I have been able to touch only on the regular inspection of one of the simplest types of boilers, while there are many different types, practically all of which are far more complicated than the one discussed.

The Manufacture of Steel Pipe

At a meeting of the Northeastern Section of the American Chemical Society in Boston, Mass., on Apr. 24, Dr. William H. Walker, of the Massachusetts Institute of Technology, gave a lecture upon the manufacture of steel pipe, reviewing the process from the sampling of ore at the mines to the testing of the finished product. A résumé of the lecture is printed herewith.

Iron is one of the most widely distributed elements in nature, but it is practically always found in combination with other substances, occurring largely in the oxide form. Chemically pure iron is extremely rare; its separation in the laboratory is a long and tedious process, and few engineers ever see it freed from combination with other elements. The production of pig iron in the United States has increased from 8,000,000 tons in 1896 to 31,000,000 tons per year at present. Forty-one per cent. of the total output comes from Pennsylvania, 23 per cent. from the Great Lakes District, 9 per cent. from Illinois, 4 per cent. from New York, and 6 per cent. from Alabama. The large coal deposits of Pennsylvania are important factors in the cheap local production of iron and steel. Some of the largest plants on this continent are the Gary, Ind., works of the Indiana Steel Co., the Lorain, Ohio, works of the National Tube Co., and the Chicago plant of the Illinois Steel Co.

The Lake Superior district is the largest producer of iron ore, and the Mesaba Range in Minnesota is the most famous present source of the raw material of the pipe industry. From the range to the steel mills of Pittsburgh, the distance is about 1000 miles. The ore beds are sometimes 600 ft. deep, with a heavy overhang. Steam shovels, efficient ore cars, excellent docking facilities and the loading of steamers by gravity are utilized to the fullest extent. An average steamer cargo of ore weighs 13,000 tons, and such a boat can be loaded in 31 minutes.

Unloading by cranes and multiple buckets consumes four hours. A modern blast furnace will produce 500 tons of iron in 24 hours, the furnace being 100 ft. high and 22 ft. in diameter at the bottom. To produce one ton of iron in a blast furnace there must be supplied eight tons of air, four tons of ore, two tons of coke and ½ ton of limestone. The furnace is tapped every four hours and the iron is tapped into sand molds or into ladles as conditions require. In a modern blast furnace 40,000 cu.ft. of air per minute is supplied at a temperature of 400 deg. C., and a pressure of 15 lb. per square inch. At Gary, all the gases of the furnaces are burned and enough power is produced by the gas engine and electric generating plant to operate the rolling mill, a cement plant and other establishments. Eight blast furnaces are installed at Gary.

From the blast furnace the iron is run into a metal mixer of 600 tons capacity, which reduces the casts from different furnaces to uniform temperature conditions, impurities being later removed in a Bessemer converter. When the iron has been purified by blowing air through the charge of metal in the converter, the charge is emptied into a traveling ladle and at the same time a certain amount of molten spiegeleisen is poured into the ladle with the iron to introduce into the metal a proper amount of carbon and manganese for the grade of steel required.

In usual practice a train of cast-iron ingot molds, with two ingots to the truck, is drawn by an engine beneath the pouring stand, and the hot metal is run into the molds through a nozzle in the base of the pouring ladle. As soon as the ingot is set, the mold is drawn from it by a hydraulic stripper, and it is lifted by an electric crane, and lowered into a soaking pit or heating furnace, where it is raised to the proper temperature for rolling. From the soaking pit the ingot is taken to the mill and passed through the blooming rolls, which reduce it in section ready for shearing into slabs and billets. Electromagnets are extensively used in handling billets. The billets in manufacturing pipe are reheated and passed through a continuous mill consisting of a large number of rolls in pairs, placed one beyond the other at increasing intervals. As the billets or slabs are carried through each successive pair of rolls they are reduced in thickness and increased in length, until they issue from the last pair of rolls in the form of long, narrow plates called "skelp."

In the narrower strips, used for smaller pipes, the width is sufficiently uniform to eliminate trimming with shears, but the skelp for large pipes has to be carefully trimmed to the correct dimensions. In lap-welding, the plate is first laid upon a traveling table and has its edges beveled. It is then heated in a bending furnace and rolled up into the form of a pipe with the beveled edges overlapping. The material is heated and passed through concave welding rolls, between which a ball-shaped mandrel of a diameter equal to the interior of the pipe, is held in position by a long bar. As the skelp passes through the rolls the overlapping edges are squeezed together between the rolls and the mandrel into a perfect weld.

The rough pipe is then passed through sizing rolls and brought to the exact diameter required; then through the cross-straightening rolls, after which the pipe is rolled on a cooling table to prevent warping, and is finally forced by a hydraulic press through the dies of a straightening machine. The ends are then trimmed and threaded, and after being screwed into the couplings, the pipe is given various bending, torsional, flanging and compression tests in a hydraulic machine. If the weld breaks the pipe is scrapped. Lap-welding is now applied to larger pipe up to a maximum length of 15 to 18 ft., and a diameter of 20 in. Test pressures vary from 300 to 3000 lb. per square inch. In the larger sizes the maker's name is rolled into the pipe, and in the smaller sizes it is stenciled upon the pipe. Boiler tubes are tested under the drop hammer by end-on blows.

In butt welding, the edges of the plate are left square. The skelp is heated to the welding point and is then drawn through a bell-shaped die, the diameter of which is a little less than that of the skelp. The pressure thus induced squeezes the edges together and makes a perfect weld. The smaller pipes are generally fitted with screwed flanges and couplings. Nothing is required in the interior of the pipe in butt welding.

The attainment of the proper temperature during the drawing process is vital to the success of the work. The larger pipes must be kept moving during butt welding to prevent sagging. There is a tendency for scale to run to the bottom and cause corrosion in butt-welded pipe. At the works of the National Tube Co. a method of overcoming this trouple has been developed for pipes up to 4 in. in diameter. The pipe is passed through rolls which pull it enough to loosen the scale, which then drops off. This treatment is of great value when a pipe is to be galvanized and has a future outlook, which is worth bearing in mind.

The Exposition's Progress

A part of the main exhibit section of the Panama-Pacific International Exposition, to open in San Francisco in 1915, is shown here. The picture was taken from the south side of the grounds. The large groups of buildings clustered on the right lie between the south gardens and an elaborately landscaped marine boulevard on the shores of San Francisco harbor. The exposition lies in a great natural amphitheater encircled on the south, east and west by the hills of San Francisco and the wooded slopes of the Presidio reservation. The picture was taken at a considerable elevation and so does not reveal the great height of the buildings.

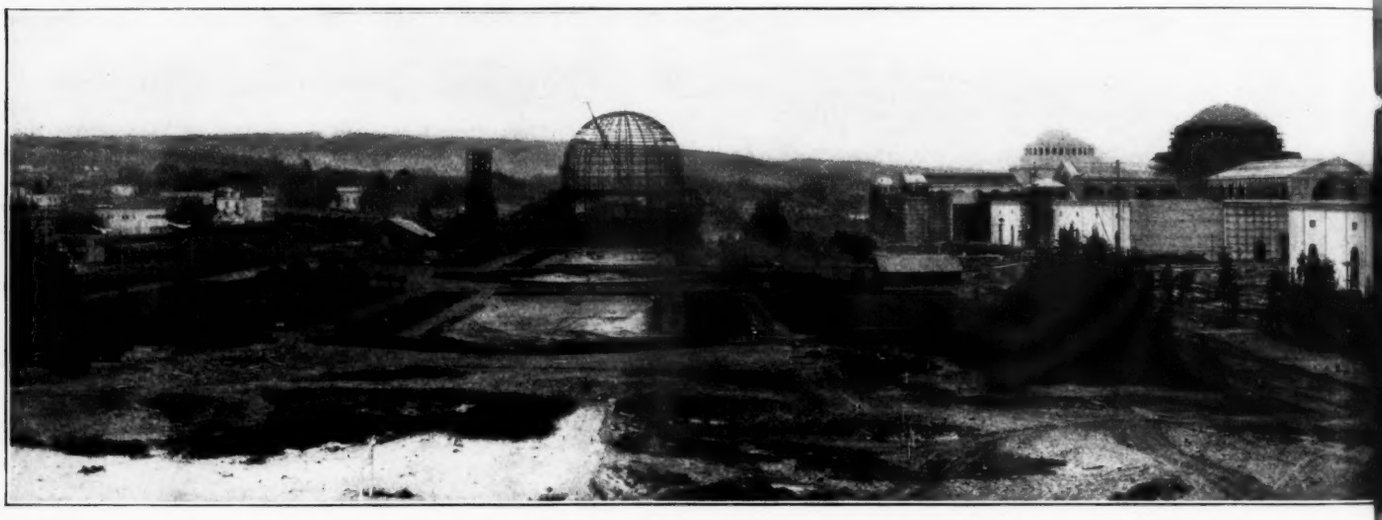
The large steel frame seen in the center of the gardens is the dome of the Palace of Horticulture. This dome is 186 ft. high and 152 ft. in diameter; when completed it will be covered with glass and at night colored searchlights will play upon it from within, giving the dome the effect of a gigantic soap bubble, sparkling and iridescent in all the colors of the rainbow.

In the foreground, before the Palace of Horticulture, is a part of the south gardens, which will be marvels of tropical transplanting.

The large group of buildings on the right has eight exhibit palaces, four of which face on San Francisco harbor, the others bordering on the south gardens. The buildings facing the south gardens are, left to right, the Palaces of Education, Liberal Arts, Manufactures, and Varied Industries; the palaces facing the harbor are Food Products, Agriculture, Transportation, and Mines and Metallurgy.

The large white dome from left to right is on the Palace of Education; this dome is 160 ft. in height and 100 ft. in diameter. The next dome, of similar proportions, is on the Palace of Liberal Arts. Next to it may be seen the dome of the Palace of Food Products. The building to the right and prominent in the picture is the Palace of Manufactures, on which the dome has not yet been superimposed. The cross naves in this palace, at the intersection of which the dome will be placed, are 110 ft. high. Then comes the dome of the Palace of Transportation, and at the extreme right appears one corner of the Palace of Varied Industries. In the opening in the center of the group and to the right of the first two domes, will be the Tower of Jewels, which will rise in terraces to a height of 433 ft. The tower will be cleft by an archway 125 ft. high, through which visitors will enter from the main gates into the Court of the Universe.

Thousands of men are at work on the grounds, and the construction is proceeding with unparalleled rapidity. Machinery Hall, with an area of nine acres, is now practically completed. Three buildings are almost finished and all of the palaces will be ready to receive exhibits on July 1.



PART OF THE MAIN EXHIBIT SECTION OF THE PANAMA-PACIFIC

Municipal Electric Plant Completed—The new $75,000 municipal electric-light plant and distributing system of Cedar Falls, Iowa, has been completed. Current is now being furnished for street lights and connections have been made with a number of factories. The new plant will gradually take over the entire electrical service from the Citizens' Gas & Electric Co., whose franchise expired some months ago.

Memorial to "Titanic" Engineers Unveiled

The unveiling at Southampton, England, on Apr. 23, of a memorial to the engineers of the "Titanic" was witnessed by 10,000 persons.

The ceremony was performed by Sir Archibald Denny, the Scottish shipbuilder, and an address was delivered by Albert W. Swalm, United States Consul at Southampton.

The memorial is a granite monument, surmounted by a bronze angel bearing a laurel wreath.

Nova Scotia Mine Boiler Explosion

An explosion occurred at the Drummond Collieries at Westville, N. S., Apr. 2, at about 9 a.m., which cost the lives of seven men and seriously injured five others. The boiler was built in 1903 by the Canadian Heine Safety Boiler Co., of Toronto, which has since gone out of existence and never had any connection with the United States company of that name. The pressure for which the boiler was designed was 165 pounds, but the safety valves were set to blow at 100 lb. and were blowing at the time of the accident.

The large loss of life was due to the presence of a number of men in the boiler house eating their morning lunch. The gist of the testimony brought out at the inquest was that the plates were lacking in ductility and that it seemed to be another case of an explosion due to a hidden lap-seam crack, to the dangers of which "Power" has repeatedly drawn attention.

Further details and photographs will appear in an early issue.

Penstock Bursts at Spiers Falls

As a result of the bursting of a penstock at the Troy electric plant at Spiers Falls, near Troy, N. Y., the evening of Apr. 21, the entire city and adjoining towns were plunged into darkness and the trolley lines tied up. The waters of the Hudson River rose and part of the United Traction Co.'s tracks on the west side of the Hudson was said to be inundated. Reports from the north say the woods are full of snow and that the rain and warm weather are resulting in a flood of some magnitude.

Offers $1,000,000 Annually for Los Angeles Aqueduct Power

The electric generating companies of Los Angeles, the Southern California Edison Co., the Los Angeles Gas & Electric Corporation and the Pacific Light & Power Corporation have agreed to buy all of the energy generated by the Los Angeles aqueduct power plants.

In a formal offer the companies agreed to pay the city a wholesale price to be set by the State Railroad Commission amounting to at least a million dollars. This is with the full understanding that the city council will protect the people by fixing a low retail rate. As an alternative the companies have offered to enter into a coöperative arrangement with the city for the public use of their complete distributing systems for five years, the city to make all rates, all contracts with consumers, read all meters, handle all money and collect all bills.

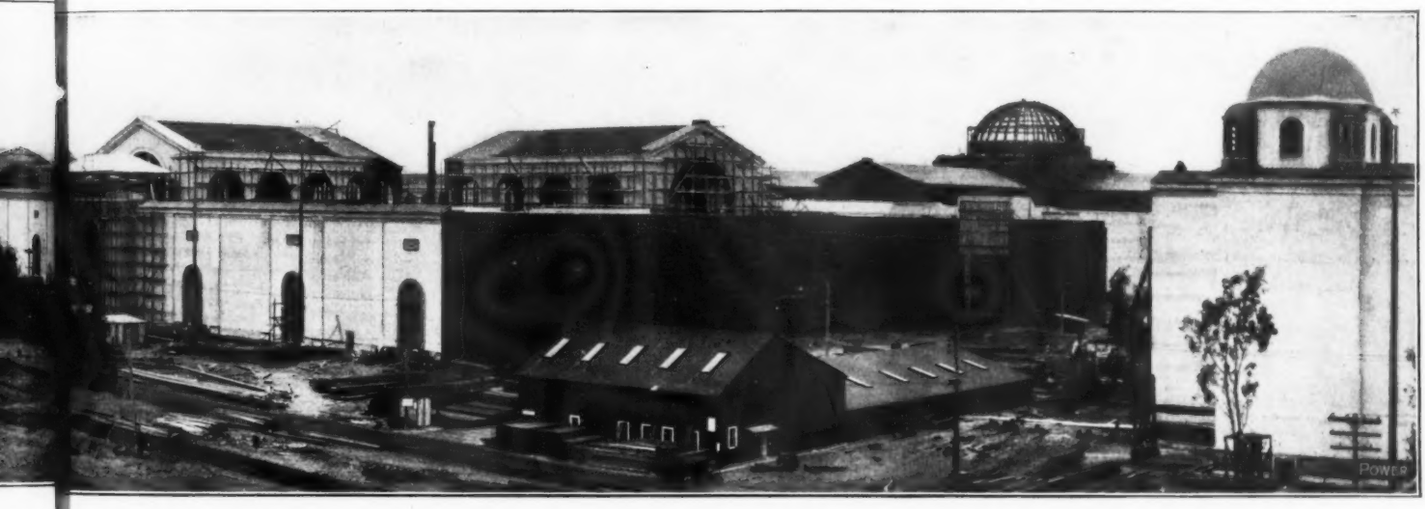
The companies will receive only the sum determined by the State Railroad Commission as equitable. It is pointed out that either of the offers will materially reduce tax burdens and that coöperation between the city and the companies for five years will greatly improve Los Angeles' financial standing.

Massachusetts "Tech" Buildings Progressing

In the construction of the new buildings of the Massachusetts Institute of Technology on the Cambridge side of the Charles River Basin at Boston, rapid progress is being made. Some 400 men are at work on the site, and the force is being steadily increased. Concrete was first poured for the foundations on Apr. 9. Three piledrivers are at work with a capacity of 300 piles per day, and an extensive lumber yard and construction mill equipment are in use.

The well of the hydraulic laboratory is practically completed and the aëronautical laboratory is ready for service. An experimental span is being erected for the electrical laboratory for transmission investigations, with two steel towers similar to the Big Creek (Calif.) installation, the span being 500 ft. Thesis work by Institute students is being pushed along civil-engineering lines, including tests of full-size concrete beams. Electrical energy for construction service on the ground is being supplied by the Cambridge Electric Light Co., a 90-kw. transformer installation having been erected for present requirements.

The buildings are being erected by the Stone & Webster Enginering Corporation, of Boston.



INTERNATIONAL EXPOSITION, TO OPEN IN SAN FRANCISCO IN 1915

NEW PUBLICATIONS

ELEMENTARY MAGNETISM AND ELECTRICITY. By Cyril M. Jansky. Published by the McGraw-Hill Book Co., 239 West Thirty-ninth St., New York, 1914. Size 6x9 inches; 212 pages, illustrated. Price $1.50 net.

This book has been prepared in connection with the extension course of the University of Wisconsin and as such is especially adapted to those who have had some practical experience with electrical machinery, but are unfamiliar with the theory and fundamental principles of operation. The experimental method of presentation is employed, and while it would be advisable if the reader could carry out these experiments which are mostly simple and require only home-made apparatus, still the illustrations and problems are such as will afford a good understanding of the subject without the actual experiments. Briefly, the subjects covered are magnetism, electro-magnetism, electromagnetic induction, the electric current, resistance, induced currents, and electrolysis. Only simple mathematics are employed and the applications are well illustrated with problems.

ENGINEERING AFFAIRS

The motion-picture lecture on the manufacture of pipe from the ore to the finished product, as given by the National Tube Co. in various cities, was delivered in the Y. M. C. A. hall, Newark, N. J., on May 5. Those in attendance were chiefly engineers, plumbers and steam users. Admission was free.

The 14th annual six weeks' summer school of the College of Engineering of the University of Wisconsin will open on June 22. Courses of instruction and laboratory practice are offered in electrical, hydraulic, steam and gas engineering, mechanical drawing, applied mechanics, testing of materials, machine design, shopwork and surveying, in addition to which subjects may be taken in the College of Letters and Science. For bulletin or for further information, address F. E. Turneaure, University of Wisconsin, Madison, Wis.

PERSONALS

E. J. Deckman, for seven years past, the representative of the Hoppes Manufacturing Co., in Pittsburgh, has become district sales manager for the Eynon-Evans Manufacturing Co., for Pittsburgh and vicinity, with an office in the Oliver Building.

W. J. Maxwell, formerly one of the chief operating engineers of the Merchants' Heat & Light Co., Indianapolis, has accepted a position as engineer of the Spy Run power station of the Fort Wayne & Northern Indiana Traction Co.

W. S. Heger has recently been appointed by the Busch-Sulzer Bros.-Diesel Engine Co. as manager of the Pacific Coast sales division, with offices in the Rialto Building, San Francisco. He has the assistance of Hugh S. Jones and W. S. Heger, Jr., as sales representatives. For 25 years Mr. Heger has been selling and installing power-plant equipment on the coast. He established the original Pacific Coast agency of the General Electric Co. in 1889. In 1895 he became the manager in the same territory for the Westinghouse Electric & Manufacturing Co., from which position he resigned after 10 years to become assistant to the president of the Allis-Chalmers Co., later returning to the coast to assume charge of its San Francisco and Los Angeles offices.

NEW EQUIPMENT

ATLANTIC COAST STATES

The A. L. Swett Electric Light & Power Co. is considering an expenditure of $6000 for the improvement of its plant at Medina, N. Y., including the installation of a 450-hp. generator and a water wheel connected to a generator.

The council of Butler, N. J., contemplates the installation of a municipal electric-light plant to cost $35,000.

SOUTHERN STATES

Plans are being considered for the installation of a municipal electric-light plant at Flora, Miss.

Plans are being considered for the installation of a municipal electric-light plant at Breaux Bridge, La.

The Russell & Burgess Hardwood Lumber Co., Memphis, Tenn., will purchase new power equipment for its plant, which is being rebuilt after a destructive fire.

The Water & Electric Light Works, of Union City, Tenn., will begin work soon on improvements to amount of $20,000, consisting of addition to building, concrete roof on boiler house, three 200 hp. boilers, smokestack (concrete), 200,000-gal. pump, and 275,000 gal. underground reservoir. C. B. Allen is preparing plans and specifications and will have charge of the work. Plans also include 250 kw. generator and engine, to be installed after boiler and pumping equipment is completed.

A company is being organized for the purpose of constructing an electric-light plant in Cadiz, Ky. Stanley White, George Smith and A. P. White, Cadiz, are interested.

The city of Sebree, Ky., will purchase boilers for a waterworks to be installed shortly.

CENTRAL STATES

J. E. Leach is making preliminary arrangements for the installation of an electric-light plant at Cheneyville, Ill.

WEST OF THE MISSISSIPPI

A. L. Peck contemplates the installation of an electric-light plant in Arnolds Park, Iowa.

The Central Iowa Light & Power Co. is preparing to install an electric-light plant in Gowrie, Iowa.

Bonds for $50,000 have been voted for the construction of an electric-light plant at Pratt, S. D.

W. F. Mulaney, Marshall, Minn., will install an electric-light plant in Cottonwood, Minn.

Preparations are being made for the installation of a municipal electric-light plant at Mintare, Neb., to cost $6000.

At a recent election bonds for $20,000 were voted for the installation of a municipal electric-light plant at Parker, S. D.

Bonds for $20,000 have been voted for the construction of a municipal electric-light plant at Manilla, Iowa.

J. B. Sterling and associates are interested in the installation of an electric-light plant at Dayton, Tex.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance.

Positions Open, (Civil Service Examinations), Employment Agencies (Labor Bureaus), Business Opportunities, Wanted (Agents and Salesmen—Contract Work) and For Sale, 5 cents a word, minimum charge, $1.00 an insertion.

Miscellaneous (Educational—Books) 10 cents a word, minimum charge $1.50.

Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York, or 1144 Monadnock Block, Chicago, will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. p

POSITIONS OPEN

COMPETENT ENGINEER to run 140-hp. De La Vergne oil engine; one capable to do all repairs; state experience and wages desired. Gifford-Wood Co., Hudson, N. Y.

WANTED, by a large company, an experienced and capable man who thoroughly understands his business, to take charge of a department working about 100 men, making elevator cars and inclosures. P. 211, Power.

Civil-Service Opportunities

Competitive examinations for the civil-service positions named below will be held on or up to the dates given. For detailed information, write the United States Civil Service Commission, Washington, D. C., or other addresses specified.

STEAM ENGINER—$900-$1500; examination May 23; for vacancy at the Capitol heating and power plant; for residents of Wisconsin only; write Wisconsin Civil Service Commission, Madison, Wis.

POSITIONS WANTED

GAS ENGINEER, seven years' experience with gas and oil engines, producers, air compressors, pumps and electric work; best reference; will go any place. P. W. 215, Power.

POSITION WANTED by engineer well versed on steam, electric machinery, a.c. and d.c. Corliss and high-speed engines; good references; Western States preferred. P. W. 210, Power, Chicago.

MECHANICAL ENGINEER, five years' experience erection and maintenance factory and power-plant equipment, building construction, handling of material in bulk and package. P. W. 216, Power.

SENIOR MECHANICAL ENGINEERING STUDENT, 22, wants employment after June 10, 1914; will do anything; lifetime experience in shops of my own; am accustomed to hard work; anything will do. P. W. 212, Power.

LET ME INCREASE YOUR BOILER-ROOM EFFICIENCY; thoroughly experienced in the combustion of fuels and the design and operation of stokers; now holding responsible position with stoker company; age 29. P. W. 213, Power, Chicago.

MECHANICAL ENGINEER, technical graduate, 30, six years' experience, thoroughly familiar with shop methods, four years mechanical engineer and chief draftsman for railroad recently taken over by a larger system; references the best. P. W. 209, Power.

WANTED—To correspond with manufacturer desiring services of master mechanic, having erecting-engineer and machine-shop experience; can handle men acquainted with all latest high-speed machines and boiler appliances. P. W. 208, Power.

SUPERINTENDENT of power of large group of power plants, desires to correspond with employers requiring the services of a high-grade power-plant engineer; thoroughly experienced in all branches, and can deliver results; only a strictly high-grade position, and salary commensurate with same is solicited. P. W. 214, Power.

WANTED

AGENTS AND SALESMEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. W. 120, Power, Chicago.

SPECIALTIES—If you recognize the value of approved specialties in an engine and boiler room as a means to higher efficiency; if you believe in this sort of thing to the extent that you think you could sell a well known boiler specialty in your territory for an old-established manufacturer in the power-plant field, write and tell us all about yourself; on receipt of your letter we will outline our proposition in full. W. 33, Power.

MISCELLANEOUS

ASBESTOS SHEET PACKING guaranteed superior; all sizes, any quantity; state requirements extreme prices, permanent supply, samples. "Manufacturer," 634 Temple Court Building, New York.

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

FOR SALE

BOILER—350-hp. water tube, used 30 days; insured 200 lb. steam pressure; cost $3500; price, $1500. Duzets & Son, Hudson Terminal, New York.

DYNAMOS—Two 75-kw. Westinghouse, 125-volt, direct connected Ames automatic engines; $975 each. Duzets & Son, Hudson Terminal. New York.

GENERATORS—Two 75-kw.-Wheeler, 250-volt, direct-connected Harris Fleming engine, with switchboards; $1200 each. Duzets & Son, Hudson Terminal, New York.

ENGINES—Five rebuilt 40- to 50-hp. Straight-Line, one rebuilt 75- to 85-hp. Straight-Line engine; all modern machines. Straight-Line Engine Co., Syracuse, N. Y.

A $10,000, 250-KW., 125-VOLT Fairbanks-Morse generator, direct connected to an American ball angle compound engine, can be had at a bargain; only four years old. Bloomingdale Bros., 3d Ave. and 59th St., New York.

1—1000 KW. FILER & STOWELL; 1—1200 kw. Rice Sargent; 1—600 kw. Allis-Chalmers. Vertical engines complete with generators and condensing plant, etc., and in good operating condition. Call or write for further particulars. Western Electric Co., Purchasing Dept., Hawthorne Station, Chicago, Ill.

NO. 21 STIRLING BOILERS—Three class A, 280 hp. each; one class A No. 24 Stirling Boiler, 320 hp., with Dorrance shaking grates, complete with fronts, drums, framework, no tubes; best condition, 160 lb. pressure, one year's use; stored ready for inspection or shipment. A. E. Staley Manufacturing Co., Decatur, Ill.

BUCKEYE STEAM ENGINES—Two at bargain prices. One 12"x21" 85 hp., 185 r.p.m., 85 lb. steam pressure; flywheel 6' 0" diam. 22" face. One 11"x18" 70 hp., 200 r.p.m., 85 lb. steam pressure; flywheel 4' 0" diam. 14" face; changed to motor drive. Must move at once. Write today. The W. H. Mullins Co., Dept. C, Salem, Ohio.

CORLISS ENGINES—1100 HP—26&42x48 Vilter Cross Compound Corliss Engine, Belt Wheel 18'. 800 HP.—22&32x42 Allis Corliss Tandem Compound, Right-hand, 18' Belt Wheel, both Engines perfect condition. Have to move immediately so make price; each engine $1050 f.o.b. cars, guaranteed excellent condition. Harold R. Wilson Machinery Co., 413 Pine St., St. Louis.